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ABSTRACT

This paper describes seven interrelated studies concerned with children's understanding of sequential actions and with the effects of observing a model on this understanding. A total of 546 elementary and secondary school students served as subjects for the studies. The tasks for all of the studies involved deriving the pattern for a sequence from a given sample so as to be able to generate a continuation of that sequence. Materials for the sequences consisted of geometric shapes and colors arranged according to rules for patterns of varying complexity. Performance was scored on the basis of the product completed and the strategy used to go about the task. Results indicated that observation of a model had the greatest impact on children who had a beginning understanding of the sequential patterns but who were not yet able to handle them competently on their own. Results are discussed in relation to the role of imitation and in relation to the role which specific contextual variables such as task design and mode of testing play in cognitive functioning. (Author/BD)

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# Children's Reproduction of Modeled Sequential Actions

Ina C. Uzgiris

Clark University

Worcester, Massachusetts 01610

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U. S. DEPARTMENT OF

HEALTH, EDUCATION AND WELFARE

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OFFICE OF RESEARCH GRANTS

Final Report

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Ina C. Uzgiris

Department of Psychology

Clark University

Worcester, Massachusetts 01610

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U. S. DEPARTMENT OF

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## Abstract

Seven interrelated studies concerned with children's understanding of the organization of sequential actions and with the effects of observing a model on this understanding are described. A total of 546 children of elementary school age served as subjects. The tasks involved deriving the pattern for a sequence from a given sample so as to be able to generate a continuation of the sequence. The sequences were made from pieces of several geometric shapes and colors and entailed rules from simple alternation to a complex coordination of repetition, rotation, etc. The performance was scored in terms of the product constructed and the strategy used in going about the task. It was found that observation of a model had the greatest impact on children who had a beginning understanding of the sequential patterns but were not yet able to handle them competently on their own. Evidence was obtained for better performance with other kinds of contextual supports as well: recognition of appropriate continuations was better than construction and memory for specific sequences was better than generation of new exemplifications of those sequences. The results are discussed in relation to the role of imitation and of contextual variables in cognitive functioning.

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In the past two decades, a change seems to have taken place in the basic assumptions concerning human nature that underlie thinking and research within American psychology. While no single inclusive theory prevails, some of the general assumptions are clear: man is seen as active, his behavior as organized, his cognitive-symbolic capacity as central to his specifically human activities. This change is strongly evident in the field of child psychology, spurred no doubt by the influence of Piaget's work, the impact of developmental psycholinguistics, and the application of notions from information theory to the analysis of children's learning. The investigation to be described in this report is congruent with this new orientation and stems from an interest in children's learning in naturalistic settings. In such settings, children often observe the activities of others in all their complexity, yet they neither copy those activities whole nor pass untouched by them; they select certain aspects of observed activities and incorporate them into their own patterns of action. The present research was undertaken to investigate how children with different cognitive capacities use a model to modify their own goal-directed actions.

The three interlinked issues suggested by this formulation of the problem - the influence of a model on children's actions, the influence of cognitive level on the use made of a model, and the sequential organization of children's actions - each yields a somewhat separate body of literature. The highlights of the literature on each of these topics will be briefly reviewed to provide a general background for the present investigation.

Imitation. Recently, there has been considerable interest in the phenomenon of imitation. The impetus for much of the research came from social learning theory (Bandura and Walters, 1963), wherein imitation or "observational learning" was proposed to account for the rapid acquisition of a multitude of new behaviors. However, other concerns have also contributed to the literature on imitation. Concern with equilibration as a theoretical mechanism in development led to studies in which models varying along a developmental progression were presented to children for observation (e.g., Kuhn, 1972; Turiel, 1969). Imitation has also been used as a technique for investigating the linguistic capacities of young children (e.g., Blank and Frank, 1971; Fraser, Bellugi and Brown, 1963). As the topic of imitation gained prominence, studies of incidental learning, social facilitation, and role-taking came to be seen as part of the same literature.

Subsequent to the classic work of Miller and Dollard (1941) in which they drew distinctions between several different types of events labeled imitation (same behavior, matched-dependent behavior, and copying), much of the recent empirical work has been directed at documenting the variety of behaviors which are subject to model influences; these include agression, altruism, phobic reactions, self-reward behavior, delay of gratification, cognitive styles, preference choices, and problem-solving strategies (for a review see Flanders, 1968). Equally numerous studies have explored factors which affect children's imitation of modeled behaviors, such as characteristics of the model (power, nurturance, competence, sex, age), reinforcement contingencies (reinforcement delivered to the subject or reinforcement delivered to the model and observed by the subject), and the medium through which the model is presented (live, film, verbally). Theoretically-oriented attempts to integrate these numerous findings and to conceptualize the process of imitation has brought forth some differences between theorists.

Gewirtz (1971; Gewirtz and Stingle, 1968) has argued that imitation can be conceptualized as a special case of instrumental learning. The first imitative responses may occur by chance and become strengthened by direct reinforcement, probably on an intermittent basis. Once several imitative responses become established in this manner, they form a class of diverse, but functionally equivalent behaviors, giving rise to generalized imitation relatively independent of specific reinforcement. A related view is held by Baer and his associates (1967), who stress the importance of the model both as a discriminative stimulus for imitation and as a conditioned reinforcer, based on the quality of behavioral similarity between model and observer which had been originally reinforced. This approach posits a period in which the general capacity for imitation is acquired, but the phenomenon of imitation is subsumed under already well-established principles of instrumental learning, in a sense doing away with the whole topic.

On the other hand, both Aronfreed (1969) and Bandura (1969; 1971) have tended to emphasize a central, cognitive component to imitation, differentiating imitation from more traditional learning processes. Aronfreed has argued that the term imitation be limited to those instances where the internal structural features of observed behavior serve as a model for the topography of the observer's own behavior. He has postulated that observation of a model's behavior results in the formation of a cognitive template, which serves as an internal representation of the model, provided that a change in affectivity is induced in the observer during the observation, which then becomes coupled to the template. A number of imitation studies demonstrating the influence of model characteristics or reinforcement variables have been reinterpreted by Aronfreed to show the importance of a change in affectivity. The important feature of Aronfreed's view is, however, his distinction between surface fidelity of one behavior to another and structural correspondence even without fidelity in detail, the latter being definitive for imitation.

Similarly, Bandura (particularly 1971) has emphasized "a representational guidance system for matching behavior which can be established without overt responding" (1971, p. 25). He isolates attentional processes, retentional processes, motor reproduction processes, and motivational processes in the sequence from a modeled event to an imitative performance. He goes on to specify that "In the social learning view, modeling stimuli serve more as sources of information than as automatic conditioners; observers often perform operations on modeling inputs so that transformational and organizational processes are involved as well as associational ones; less structural correspondence is assumed between memory codes and the original modeled patterns; verbal representation is assigned a greater response guidance function; and reinforcement ... is treated ... as a factor that can facilitate observational learning" (1971, p. 26). While this formulation clearly separates the process of imitation from more traditional learning, it deprives the notion of distinctiveness by merging it with perception, representation and memory. In fact, Bandura posits four modeling effects: (1) inhibitory effects, produced when the model's behavior is observed to lead to punishing consequences; (2) disinhibitory effects, produced when models are observed to engage in threatening or prohibited activities without adverse consequences; (3) response facilitation effects, produced when others are observed to engage in the performance of pre-existing responses of a general type; and (4) observational learning effects. Observational learning is thought to entail the organization of available response components into new forms of patterned behavior. Bandura stresses that most new complex responses are composed of common behavioral elements, and thus, such recombination qualifies as new response acquisition. The capacity for observational learning is presumably inherent to man and any change in imitation of models with age would have to be accounted for by means of other processes (attentional, retentional, etc.) entering into the imitation situation.

Few studies have examined children's age as a variable in observational learning (Hartup and Coates, 1970). Most studies have used preschool children as subjects and treated them as a single age group. A few have sought age differences, but found none (e.g., Hetherington, 1965). However, age as an indicator of level of development has been much more salient for investigators concerned with the match between the cognitive demands of the activity modeled and the cognitive capacity of the observer.

In conclusion, the empirical studies on imitation demonstrate that models influence the subsequent actions of observers in a variety of situations; due to the theoretical framework within which these studies have been conducted, they do not address a number of parameters of the imitation situation. First, since the model's actions are conceptualized in terms of "responses", the frequency of all or individual target responses of the model shown by the observer is recorded, but no attempt is made to examine the sequencing, regularity, repetition, etc. of those responses. In short, it is not considered that the observer may see in the model's behavior an integrated action rather than a series of isolated responses. The imitation of non-target responses is also ignored. Second, since ability to imitate is assumed to be inherently present (Bandura) or firmly established by preschool age for normal children, differences in imitation with development have not been systematically studied. Third, the process of attaining a match in overt behavior has not been empirically investigated.

Cognitive Match. Investigators inclined to emphasize cognitive and structural factors in development have not been much concerned with the phenomenon of imitation. They have mostly used modeling as a technique to demonstrate the limited import rather than the pervasiveness of observation effects. Starting with Piaget (1951), who recognized in imitative phenomena the accommodatory pole of adaptation, they have emphasized the cognitive structures of the observer (rather than the objective features of the model) as primary in determining the impact of the observation. In his works, Piaget has remarked in several places that demonstrating a solution does not lead to its adoption by the child until the child is able to generate the solution himself through the development of his own reasoning. This stance has been most directly examined by investigators attempting to shift the level of children's functioning.

In a study of the development of moral thinking in children, Turiel (1969) reasoned that if progress involved a restructuring in the level of thinking, exposure to reasoning at one stage above that of the child's should have greater impact than exposure to reasoning one stage below or several stages above. Turiel's findings generally confirmed his expectations, more strongly for situations which were used in the modeling than for new situations. A similar design was followed by Kuhn (1972). She pretested children on a classification task and then had them observe an adult perform the classification task at a level one stage below, one stage above, or two stages above that of the child. The effect of observation was assessed immediately and at a later post-test. The results were not completely clear-cut, but more pervasive change was induced by models demonstrating a more advanced classification performance than the child's, supporting the hypothesis of hierarchical development. Taken together, these studies lend support to the attribution of a significant role to the observer's cognitive level in determining the impact of a particular demonstration. Imitation research from a cognitive perspective has been reviewed by Kuhn (1973).

In contrast to these findings stand reports of apparent success in changing the level of performance in cognitive tasks by means of modeling from investigators who do not share the developmental perspective. For example, Bandura and McDonald (1963) have claimed to have shifted the level of moral thinking to more advanced or less advanced when compared to the pre-test depending on the level modeled. Similarly, Sullivan (1969) has induced conserving responses in children by exposure to conserving models. Methodological difficulties prohibit an unequivocal interpretation of the changed responding of the subjects in both these studies, but further exploration of the conditions under which modeling may be an effective training technique seems to be desirable.

A study that clearly demonstrates the importance of the cognitive requirements of a task for imitation was reported by Wapner and Cirillo (1968). Their subjects, ranging in age from 8 to 18 were required to imitate the hand movements of a model. These movements could be carried out with either the left or the right hand to either the right or the left side of the body. The results indicated that understanding of left-right relations was necessary for correct imitation, which consequently increased with age, but was not required for inexact imitation, which was found not to be age related. This study also points out the importance of looking separately at different aspects of the model's behavior.

In conclusion, it appears that several problems merit further exploration. First, the relationship between the cognitive capacities of the observer and the cognitive requirements of the modeled task need to be more systematically studied. The experimental tasks may have to be less purely cognitive in order to permit the child to construct and reproduce the modeled activity in different modes, not only in different degrees of similarity to the model. Second, it may not be reasonable to assume that a single modeling episode would reveal the full impact that observation of the activities of others can have. Unless representations are literally taken to be "templates", observation and performance may have to alternate several times before the impact of the observations is revealed.

<u>Sequential Organization of Actions</u>. The problem of the sequential organization of behavior is addressed most clearly in studies of serial verbal learning and of motor skill acquisition. The literature in both these areas is enormous, particularly if not limited to studies using children as subjects; only a few illustrative papers will be mentioned in order to highlight some issues pertinent to the present research.

Highly competent motor performances as well as the productive use of language make it clear that associative or chaining theories cannot account for the organization and flexibility of such behavior. Lashley's (1951) classical paper emphasized that the essence of "the problem of serial order in behavior" revolves around the implication of a generalized pattern or schema of action which determines the sequence of specific acts, acts which in themselves seem to have no temporal valence. Psychology has periodically returned to this problem.

One thread of search evident in many studies pertains to the relationship between component units and the sequential task as a whole. Investigators appear to be divided on whether the component units are perfected within the overall schema of the task or whether they are first perfected as individual units and then become available for inclusion in a generalized action schema. Bruner and his associates (1968a, 1968b, 1970) have studied the development of skilled actions such as voluntary sucking, reaching, and grasping, coordinated use of both hands, and detour reaching in young infants. He has conceptualized skill development as a series of qualitative steps, with consolidation at one step permitting a new program of action to be adopted, which in turn has to be consolidated. "The beginning of skill is diffusely organized awkwardness guided by a small number of directional specifications" (1968a, p. 253). Bruner calls the process of consolidation "modularization", since he thinks that only modularized actions can become incorporated into new, more inclusive, and more complex serial patterns. Prior to modularization, an act takes up all the attention available, hindering aiming at a more distant goal. Once attention is freed, a new program of action may emerge in one of three ways: (1) by repetition, so that the modularized act becomes a sub-routine in an extended repetitive sequence; (2) by integration, so that a more remote goal takes control of the modularized act; or (3) by elaboration, involving a breaking-up into more restricted components and then a regrouping of them into a modified pattern. Bruner suggests that the components are always perfected within a more general pattern of action, and implies that they are hierarchically arranged with substitution rules and functionally equivalent variations within the general goal-directed framework to assure flexibility and generativity.

On the other hand, investigators coming to the problem from more traditional theoretical perspectives (e.g., Kay, 1970) have emphasized the learning of probabilities between components of a sequential action. Once the information load is reduced as a result of increased predictability, fluency and efficiency characteristic of skilled performance becomes possible. There is not a great deal of empirical evidence on this issue, since most studies have not monitored children's performances in enough detail to permit analysis of the execution of sub-routines within a sequential act. The most frequent measures used have included latency, total time of execution, and error scores. All these measures decline with practice, and time of execution seems to decline with age (Connolly, 1970), but the lack of information for a variety of tasks prohibits firm conclusions.

The notion of "schema", "plan", "program" or "image", however named, is central to all non-chaining views of sequential performance to point to the atemporal quality of the directedness-generating mechanism. It has to be seen as the source of the qualitative differences in the general approaches adopted in the course of skill acquisition or with development. Some studies suggest that verbal symbols may be intimately involved in this function; however, the evidence on the importance of visual feedback for various motor performances implies that response images may also be involved.

Furthermore, the similarity of this problem to the problem of the "template" in imitation, and particularly delayed imitation must be pointed out. In so far as imitation is thought to lead to acquisition of new patterns of action rather than to single responses, formation of a program for action through observation must be thought possible. This implies that an observer must be able to abstract from the actions of another the plan guiding those actions as well as to use it to guide his own actions during reproduction. One study in the sphere of verbal behavior (Rosenthal, Zimmerman and Durning, 1970) has specifically compared the effect of a model's example on question-asking by children in terms of the amount of exact mimicry versus imitation of question type. While a strong model effect was found, there was little exact mimicry, suggesting acquisition of a general rule.

A great deal of recent work in skill acquisition tends to view the individual as an "information-processor", a self-regulating servo-mechanism. The task to be mastered is thought to present inputs which need to be perceived, processed, and converted into output actions, which then become part of the information input to be processed. Efficiency in performing a task is thought to depend on the information load of the task for the individual. An intimate tie between attention and information-processing is frequently implied, so that the freeing of attention from a sub-routine may be taken as a measure of increased certainty in the task. Since older children are assumed to be able to process more information per unit time, their performance is expected to be more efficient when the tasks are of sufficient complexity. Similarly, with practice, as sub-components of a task become routinized and their sequential probabilities become known, reducing uncertainty, the efficiency of performance increases. While empirical results support these expectations (Connolly, 1970), the information-processing approach does not provide a satisfying interpretation of the sequential organization of actions in general. The qualitative changes taking place tend to be obscured by essentially quantitative evaluations of performance.

In summary, the literature on skill acquisition points to several important topics for any consideration of sequentially-organized actions. It seems that a generalized program provides organization and directionality for sequential actions at any stage of their perfection. The generalized programs are likely to depend on the cognitive level of the individual. Nevertheless, the actual implementation of a generalized program in action may be necessary for the acquisition of some types of knowledge, suggesting that monitoring of a series of actualizations of a generalized program by an individual may provide valuable information regarding its limits. The ability of an individual to make use of an external model in shaping or perfecting the generalized program for action needs further exploration.

Research Perspective. The present investigation aimed to gain understanding of how children varying in age (and in level of cognitive development) construe a sequential action modeled by an adult as shown through their reproduction of that action in several serial attempts. In general terms, the considerations of importance for this investigation were as follows:

1. The modeling of an integrated complex activity. The presentation to the child of an activity that could be construed in a number of different ways and reproduced at several different levels was considered important to gain an understanding of the interplay between the child's cognitive capacity and the effect of observation.

2. The modeling of sequentially organized activity. The modeling of activity consisting of delineated units and groupings of units was thought important to permit evaluation of the organization of the activity in the child's reproduction. The aim was to gain understanding of the "generalized program" for action that children of different ages adopt after an observation of a complex activity.

3. The use of activities having a strong cognitive component. In order to examine changes in reproduction due to changes in the construal of the model's activity and those due to possible changes in some general tendency to imitate others, it was thought important to work with tasks requiring cognitive effort on the part of the children studied.

4. The use of children varying in age. The use of age groups which would be expected to span a major qualitative shift in cognitive functioning (e.g. from pre-operational to concrete operational thinking) was considered important in order to insure varying construals of the model's activity.

5. The elicitation of repeated attempts to reproduce the modeled activity. It was thought that reproductions may change over a series of attempts due to changes that the organization of the activity may undergo with repetition and also due to the feedback gained from the repeated observation of the model and of the product of the activity even without extrinsic reinforcement. It was considered important to use tasks that are suitable for repeated performance.

Within this general framework, a series of specific experimental studies was carried out. Each study will be described separately, since different methods and procedures were employed for different studies. A concluding statement follows the presentation of the empirical work.

## Study I

### The Effects of Modeling on Design Construction by Children

Numerous studies have demonstrated that children's behavior in a situation can be influenced by the observation of a model performing in a similar situation. In recent years, the tendency has been to discuss the modeling effect in terms of the information that the model's actions provide for the observer rather than in terms of associative mechanisms or of motivational processes. In keeping with this theoretical trend, research has focused on behavior in rule-governed situations and has contrasted the effectiveness of modeling with other techniques for conveying information to the subject (e.g. by direct verbal instruction). A review of the literature showed, however, that a number of variables pertinent to interpreting modeling effects in cognitive terms have been insufficiently addressed in previous research. The goal of this study was to examine the effect of a number of such variables on children's performance in a non-verbal, rule-bound task in order to determine those variables worthy of more intensive investigation. A secondary goal of this study was to ascertain the suitability of the design construction task for the purpose of this research.

If the model's behavior is viewed as a source of information for the observer, the observer's ability to use this information becomes of central importance. Changes in cognitive ability that take place with development might be expected to become manifest in the success with which children utilize the information provided by a model. Although age can serve only as a crude index of cognitive level, studies of modeling effects on children varying in age (and presumably in cognitive level) have been relatively rare. Hartup and Coates (1970), reviewing research on imitation by children, pointed out the scarcity of information on age differences in the effects of observing a model. In their review of studies on observational learning of rule-governed behavior by children, Zimmerman and Rosenthal (1974) did not even consider age differences.

In an early study, Coates and Hartup (1969) demonstrated that 7-8 year old children were significantly better able to reproduce a series of specific actions demonstrated by a model than 4-5 year old children. This age difference was not significant when the children were instructed how to describe the model's actions during the demonstration. Thus, the age difference presumably reflected a difference in the spontaneous use of verbal coding strategies to facilitate memory rather than any difference in ability to utilize the information provided by the model. In a more pertinent study, Denney (1972) found that different question-asking strategies modeled for 6, 8, and 10 year old boys affected the three age groups differently. The most complex strategy did not affect the behavior of the youngest group and the least complex strategy influenced only the middle age group, who gave up to some extent their more complex spontaneous strategy for a less complex one upon exposure to the model. These results point to a possible interaction between cognitive ability to utilize the method demonstrated by the model and factors of social compliance. Similarly, Oliver and Hoppe (1974) found that kindergarten children were not influenced by observation of a model's unreinforced behavior so as to deduce that the alternative would be reinforced; second grade children were so influenced. However, the second grade children also seemed to be sensitive to the social aspects of the situation, since they chose the reinforced alternative significantly more often only when the unreinforced model was absent from the room. Interpretation of the findings from this study is complicated by the fact that fourth grade children were found to be little influenced by observation of the unreinforced model, although cognitively they should have been able to deduce that the alternative response was correct.

Attempts to test Piaget's stage model of cognitive development have come closest to examining the role of cognitive level in responsiveness to a given model. Studies by Turiel (1969) and Kuhn (1972) suggest that children exposed to reasoning one stage above their own seem to be most affected by the experience. Recently, Murray (1974) examined the effects of modeling on children's responses to a conservation problem. He concluded that modeling was effective when it was in developmentally sensible direction and only for children who were cognitively open to grasp the understanding modeled (i.e., in transition for the concept). Thus, the available studies suggest that the observer's cognitive level is a factor in determining the effect that observation of a specific model will have, but, additionally, that factors pertaining to the experimental situation also play a role in determining the child's behavior.

In the present study, children from kindergarten, second, fourth, and sixth grades were studied. Pilot testing indicated that preschool children would not perform in a task having the desired characteristics; consequently, kindergarten children constituted the youngest group included. It was assumed that the age groups chosen represented different levels of cognitive ability. It was hoped that the study of four age groups on the same task would contribute to the understanding of developmental trends in modeling effects.

A second important facet of this study was the behavior to be modeled. If the observer is viewed as an active organizer of his activity, actively processing the information contained in the model's actions and actively constructing his own handling of the same task, then the modeling must involve rule-governed, sequentially-related, and goal-directed behavior. There have been relatively few studies in which such modeling was used.

Most of the earlier studies selected for modeling several discrete acts which could be inserted within some ongoing activity. In trying to ensure that the acts modeled would be novel and, thus, unlikely to be seen in the spontaneous behavior of children, the studies usually centered on acts arbitrarily related to the main activity. For example, Bandura and Huston (1961) modeled marching, doll-hitting and verbalizing in the course of selecting the box which contained a reward. At most, the modeled behaviors may be seen as embellishments of the action of choosing the appropriate alternative. In studies of this kind, the personal characteristics of the model and the nature of the relationship between the model and the observer have been found to be important determiners of the modeling effect.

Many of even the more recent studies concerned with observational learning of concepts or rules have selected fairly arbitrary concepts for modeling. For example, Zimmerman and Rosenthal (1972), and Rosenthal and Zimmerman (1973) studied the effect of modeling on acquiring a rule that an arrow's color in a display is to be matched by the color of the spools selected and that a position of the arrow designates the number of spools to be picked. Although the task does involve the learning of a rule, the rule itself is quite arbitrary. Similarly, Rosenthal, Alford, and Rasp (1972) studied the behavior of children in a clustering task, where the rule demonstrated by the model was to take an object from each object class so that no two objects would be of the same color. While following of this rule grouped all the objects effectively, many other rules might be devised to sensibly partition a set of multi-colored objects. Somewhat inherently less arbitrary rules that have been modeled include classifying objects on the basis of a non-preferred dimension (Kobasigawa, 1970) or pointing to the identical or different picture in a matching-to-sample task (Zimmerman and Rosenthal, 1974). The previous studies that come most closely to modeling a non-arbitrary approach to a task all involve the 20-questions game (Denney, 1972; Denney, Denney, and Ziobrowski, 1973; Denney and Connors, 1974; Loughlin, Moss and Miller, 1969). Strategies for playing this game vary with age and they can be ordered on the basis of their effectiveness; thus, children can be exposed to a strategy they do not use spontaneously, but which is inherently preferable if one is to win the game. In these studies, however, the strategy is evident in the verbal behavior of the model and the distinction between modeling and verbal instruction becomes harder to draw. Consequently, a non-verbal task was chosen for the present study.

Third, because the rules or concepts to be acquired through observation were frequently arbitrarily related to the task at hand in previous research, the subjects in those studies had to be specifically instructed to follow the model's behavior. For example, Zimmerman and Rosenthal (1974) instructed their subjects in the matching-to-sample task: "Point to the same thing she points to and say what she says." Or, Zimmerman (1974) told his subjects in a stimulus grouping task to "Play the game just like the lady did." With such explicit instructions to imitate the behavior of the model, it is difficult to separate the social influence effect of the situation from the observational learning effects. It is possible to argue that observers adopt the model's strategy in order to meet the request of the experimenter. In a situation where the model's behavior is rather arbitrary, the effectiveness of observation might be determined by the personal characteristics of the model and the relationship of the observer to the experimenter just as it was found to be in the earlier studies of imitation of novel, discrete behaviors. Testing for generalization of the modeling effects as well as for retention of the rules learned has been included in many studies so as to demonstrate that observational learning has taken place. However, to the extent that the generalization tasks are quite similar to the training tasks and do not contain an inherently correct solution, generalization due to social compliance cannot be ruled out. Consequently, it was judged important for the present study to select a task that could be solved in a number of different ways. The model, then, might demonstrate an inherently effective way for carrying out the task, but the observers would have available alternative ways for handling it.

When a sufficiently complex task is used, a distinction can also be made between the process of carrying out the task and the product or outcome. For example, different strategies can be used in the 20-questions game, and any of them may some . lead to a correct identification; the achievement of correct identification does not uniquely indicate the use of a particular strategy. Most studies in the literature have relied on the association of the use of the modeled strategy, rule, or concept and a particular task solution to infer the use of the former from the latter. Scoring has been largely in terms of the product of the activity rather than the process of going about it. In the present study, it was decided to record the approach to the task used by the children in order to have measures of the process of carrying out the task as well as of the task outcome. A number of specific aspects of the process of carrying out the task were considered important to assess in order to capture the sequential, organized nature of goal-directed activity.

Previous research has not examined systematically any differences between modeling that is inherently task-related and modeling that is incidental to the main task. Studies focusing on modeling of novel, distinct acts have generally used preschool children and have presented these acts within no specific task, i.e., a play context, or as incidental to a task. On the other hand, studies focusing on modeling of a concept or a rule have used a task requiring the concept or rule to accomplish it successfully. One exception is a study by May (1965), who compared imitation of relevant and irrelevant aspects of the model's behavior in a two-choice discrimination problem. A difference between these two aspects was obtained in that both 3 and 5 year old children imitated the model's choice in the discrimination problem equally, but the 5 year olds imitated the model's irrelevant behaviors more than the younger children. A similar study has not been conducted with a wider age-range. It is possible that the older children assumed an implicit instruction to imitate the model in all respects, since it has been reported (Kuhn, 1973) that older preschool children tend to interpret an ambiguous instruction as an instruction to imitate the model. It is conceivable that at later ages, children would interpret the situation more flexibly and imitate irrelevant aspects of the model's behavior less often. Consequently, in the present study, the model demonstrated both a strategy for carrying out the task as well as several task-irrelevant behaviors.

Finally, it was thought worthwhile to examine the effects of modeling over several repetitions, since a single exposure to a complex strategy may be insufficient for a child to process the information available. Although it might have been desirable to use a greater number of repetitions, due to time constraints, three repetitions of the task performance were used in the present study.

In short, the present study focused on the modeling of a complex activity, non-verbal in nature, the making of a linear design from geometric forms. The task required sequential organization of actions for its execution, yet it was one that could be executed in several different ways and lead to the same end-product. It was a task within the competence of the youngest subjects to carry out in some fashion; the model demonstrated a reasonable alternative way for carrying out the task. While a general strategy guided the model's actions, it could not be readily formulated into a simple verbal rule. Thus, in this case, demonstration might be considered the normal means for conveying the information embedded in the model's actions. In addition, several discrete acts incidental to the making of the design were also modeled in order to allow a direct comparison of the effectiveness of modeling for these two types of behaviors. The effect of the model on the child was assessed in terms of the modification of the child's way of carrying out the task as a result of observing the model's way of going about it. The model's way of carrying out the task was not characterized as "good" or "correct" and the subjects were not specifically told to act like the model.

## Method

Subjects. A total of 96 children participated in this study. They were obtained from two public elementary schools located in lower-middle class neighbourhoods in Worcester, Mass. Twenty-four children, equally divided by sex were tested from kindergarten, second, fourth, and sixth grades. The children within each grade were randomly assigned to one of three experimental conditions.

Materials. The linear design to be constructed by the model and by the subjects was made up of 37 geometric pieces. The pieces were cut out from 1/4 in. thick masonite in the following forms: square, circle, triangle, ellipse, diamond, and rectangle. The individual pieces generally fit within a 1 1/2 in. square, except that some rectangles were both narrower and taller. The pieces were painted in several different colors. The completed design is portrayed in Figure 1. It was considered to be composed of eight units, as indicated in the diagram.

A wooden box (30 in. long, 12 in. wide, and 2 1/2 in. deep) with 24 compartments arranged within three rows was used for keeping the pieces for making the design. Identical pieces were grouped into separate compartments in order to minimize the problem of finding the desired piece. This supply box contained duplicates of all the pieces used in the design and some pieces in colors other than the ones needed for the design.

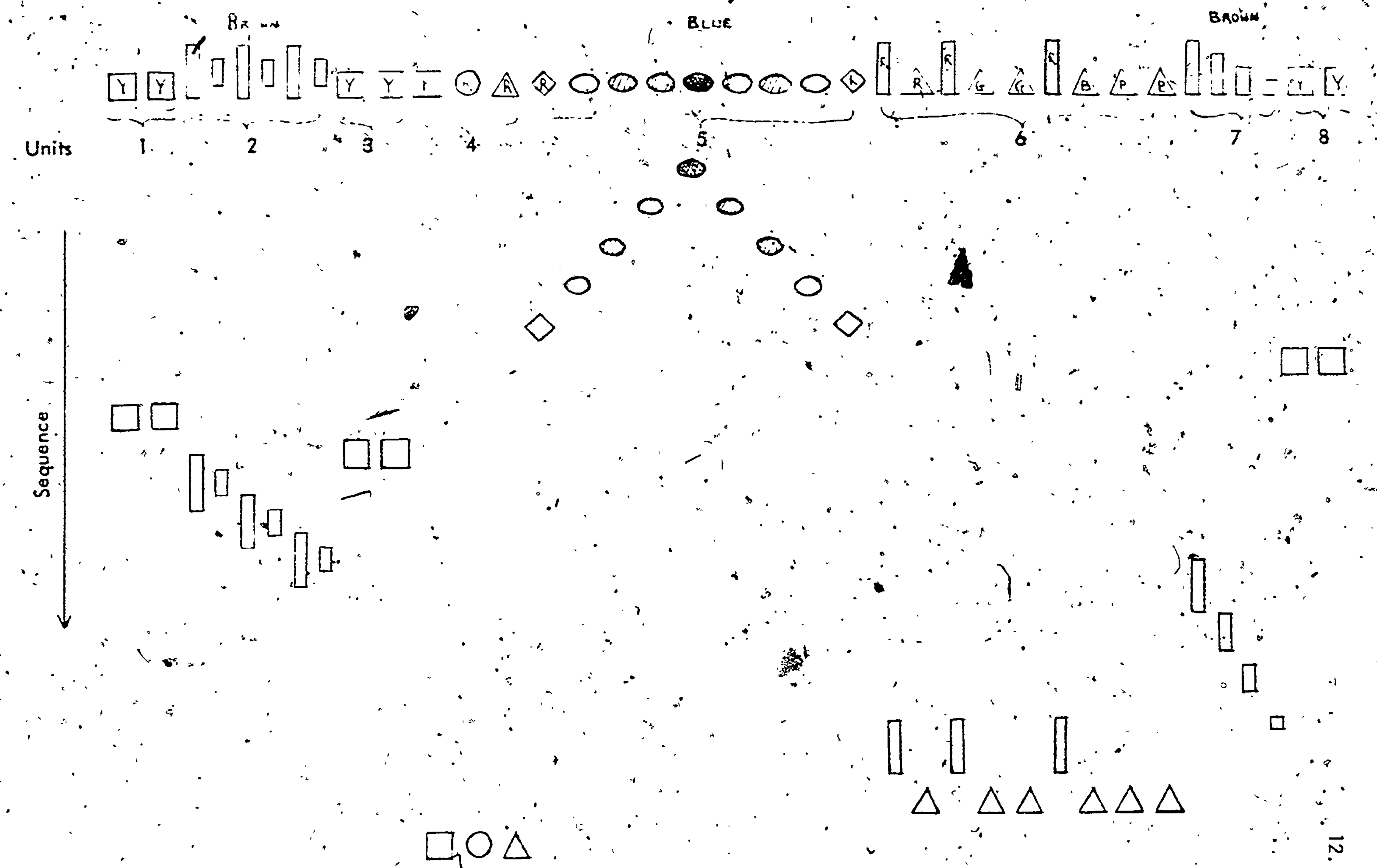



Figure I. Schematic representation of the sample design and the sequence used by the model in making the design

A listing of all the pieces provided and their locations in the box is given in Appendix Table A: 1.

This box was located on a separate table from the one on which the design was built. In addition to this supply box, four smaller wooden boxes were stacked on the corner of this table. These smaller boxes measured 11 in. by 13 in. and had three unequal-sized compartments. They were available for transporting selected pieces from the supply box to the work table.

Wooden boards measuring 5 in. by 60 in. and covered with metal on the top surface were used as the base for building the design. The geometric pieces had small, circular magnets glued into their backs and, therefore, adhered to the metal. When spaced about 1/2 in. apart, the pieces used in the design filled the board from end to end.

Procedure. Each child was tested individually in a spare room in the child's school. An adult female introduced the children to the task and served as model for those in the modeling conditions. A second male experimenter was present and videotaped the sessions for later analysis.

The experimental room contained a large table on which the designs were built. At a right angle to this table and about 4 ft. away, there was a smaller table containing the supply box and the containers. A chair was placed between the two tables, permitting a good view of the activity at both; the child was asked to sit in this chair during modeling and the model used it while the child was constructing the design. During each trial, the board containing the sample design was hung opposite the supply table, requiring a definite turn in order to view it from either table. The lay out of the experimental room is depicted in Figure 2.

Three different experimental conditions were used. In the No Model (NM) condition, the child was shown the ready-made sample design and asked to proceed to make an identical design on the work table. Hence, this condition may be viewed as a control group for modeling and as a group which received information about the task only through exposure to the desired end-product. No instructions as to how to proceed were given. In the Model-and-Design (MD) condition, the children were asked to first watch the model make the design and told that they would have a turn afterwards. The model demonstrated the making of the design before each trial given to the child. In this condition, the children may be considered to have had two sources of information about the task, observation of the model's actions in making the design and the desired end-product which was also available while the child built his design. Children in the third conditon, the Model-No Design group (ND) were treated identically to the children in the Model-and-Design condition, except that once they had inspected the completed design for about 15 seconds, the sample design was removed and they had to proceed from memory. Thus, although performance of the ND group would be expected to be highly influenced by memory factors, this group may be viewed as having to derive information about the task mainly from observation of the activity of the model during design construction.

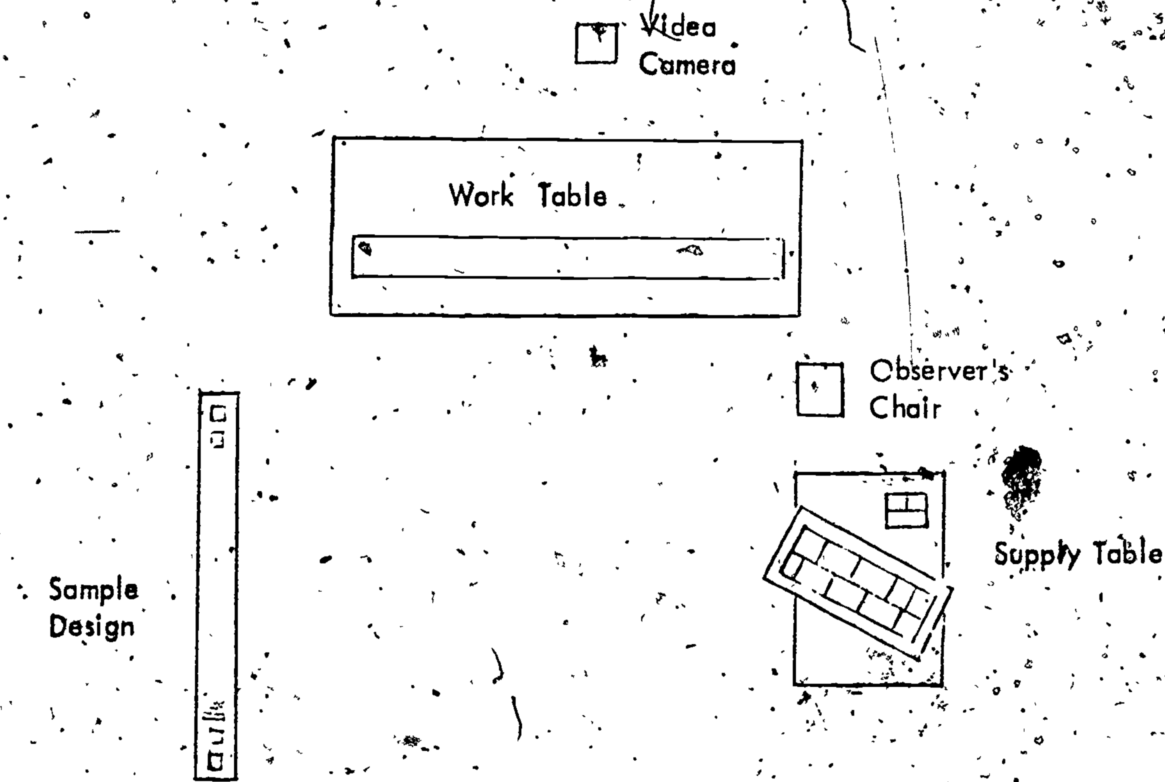



Figure 2. Schematic representation of the lay-out in the experimental room

The strategy demonstrated by the model had several distinct characteristics: (1) The model showed planfulness: she used one of the containers to gather the necessary pieces for the making of the design; she picked up the pieces by types (yellow squares, triangles, brown sticks) and placed them into separate piles in the container; she carried these supplies to the work table and surveyed the work board as if to plan the lay-out of the pieces. (2) The model treated the design as made up of sub-units: she removed pieces from the container in units, deposited them on the board in units, and made definite pauses after laying down each unit; once the design was completed, however, all the pieces on the board were equidistant from each other. (3) The model treated the design as an organized whole: she started to make the design with the unit at the center and switched from working on one side of the design to the other several times. The sequence of actions in building the design used by the model is described in Appendix Table A: 2. The model also exhibited ten distinct behaviors while working at the two tables such as blowing on a piece, rubbing two pieces together, depositing the container back on the supply table after completing the design, verbalizing about the pieces, and so on.

Upon entering the experimental room, each child was told explicitly that the task was to make a design identical to the sample design which was already built from the pieces located in the supply box. Children in the MD and ND conditions were shown to the chair and asked to observe the model make the design before taking their turn. Children in the NM condition were asked to go ahead and do it. All children were informed that they would make the design three times. Children in the ND condition were also informed that the sample design would be removed prior to their turn at building the design. No reinforcements were given to the model or to the children in any of the conditions. After the last trial, the children were questioned about their strategy in building the design and about what they saw as units in the design. These responses were video-taped as well.

The children's performance was assessed in terms of several dimensions: (1) accuracy of the completed design; (2) efficiency in making the design; i.e., time to complete the design; and (3) evidence for the influence of observing the model in terms of (a) direct imitation and (b) differences in strategy of going about the making of the design compared to the NM group.

## Results

The specific measures that were coded and their reliability is reported in Table 1. Reliability was determined by having two judges independently code the video-tapes of 24 subjects (six from each condition). It was found that the measures could be coded fairly reliably.

Since preliminary analyses indicated that the child's sex was not a significant factor in performance, all the results are presented for boys and girls combined. For most measures, analyses of variance with age, condition, and trials as factors were run and then followed up by post-hoc comparisons of means or trend analyses.

Grade and trial effects were obtained on most measures, indicating greater facility in performing the task with age and with repetition. There were almost no grade by trial interactions. The effect of trials will be discussed only when it modifies the effect of other variables.

Table 1

Reliability of Measures Coded from the Video-Tapes
Given as Correlations Between Two Coders or Percentages of Agreement

| Measures | Conditions NM | MD | ND | Overall |
|---|---|---|---|---|
| Number of Errors | 71% | 92% | -[a] | 81% |
| Number of Self-Corrections | 71% | 83% | 71% | 75% |
| Total Time | .99 | .99 | .99 | .99 |
| Organization: | | | | |
| Number of Steps | .93 | .99 | .99 | .97 |
| Number of Chunks | 93% | 91% | 76% | 88% |
| Between-Unit Pauses | .89 | .80 | - | .87 |
| Within-Unit Pauses | .99 | .97 | - | .91 |
| Returns to Supply Table | .99 | .99 | .97 | .99 |
| Checking of Sample Design: | | | | |
| Checks at Supply Table | .96 | .97 | - | .97 |
| Checks at Work Table | .94 | .97 | - | .97 |
| Between-Unit Checks | .71 | .97 | - | .97 |
| Within-Unit Checks | .90 | .86 | - | .87 |
| Imitations: | | | | |
| Container Use | 100% | 88% | 100% | 96% |
| Type of Progression | 100% | 83% | 71% | 85% |
| Placement Forward | 88% | 67% | 58% | 71% |
| Crossing Center | 100% | 67% | - | 65% |

[a] In the ND condition, some measures could not be coded because only fragments of the design were built.

Accuracy of the product. In terms of the number of pieces placed in their correct positions, children in the two conditions where the sample design was available to them during performance of the task (NM and MD) were clearly more proficient than children in the ND condition. As can be seen in Table 2, from second grade on, children in the NM and MD conditions made very few errors. A 4 (grade) x 2 (conditions NM and MD) analysis of variance on the total number of errors summed across trials indicated that the grade effect ($F = 19.42$, df 3, 56, $p < .01$) as well as the grade by condition interaction ($F = 5.14$, df 3, 56, $p < .01$) was significant. The interaction is due to the greater number of errors made by kindergarten children in the NM condition (Duncan's test on means; $p < .01$) and a non-significant increase in the number of errors for grade 6 children in the MD condition, indicating that the condition effect on errors decreases with age. The errors most frequently made by children in the NM condition consisted of omission of pieces and substitution of pieces; it seemed that the NM children had greater difficulty in keeping track of their place in the design, since they adopted the strategy of piece-by-piece copy of the sample design. The most frequent error made by grade 6 children was failure to use appropriately shaded pieces in unit 5, the large central unit (see Figure 1). A trend analysis indicated that there was a significant decrease in the number of errors with grade only in the NM condition.

Table 2
Mean Number of Errors for all Three Trials

| Condition | Grade K | Grade 2 | Grade 4 | Grade 6 |
|---|---|---|---|---|
| NM | 22.7 | 5.1 | 2.2 | .87 |
| MD | 10.7 | 3.6 | 2.1 | 5.5 |

Since errors could not be determined accurately for the ND condition, Table 3 presents the number of correct pieces placed in the design for all three conditions. As shown in Table 3, children in grades 4 and 6 placed over 60% correct pieces even in the ND condition from the second trial on. Thus, it may be concluded that children in all the conditions had a way of performing the task with fair success.

Table 3
Mean Number of Correct Pieces (out of 37)
Averaged Over Three Trials

| Condition | Grade K | Grade 2 | Grade 4 | Grade 6 |
|---|---|---|---|---|
| NM | 31.5 | 35.6 | 36.5 | 36.7 |
| MD | 34.6 | 36.2 | 36.4 | 36.0 |
| ND | 16.4 | 19.8 | 23.9 | 27.1 |

Time to complete the design. The total time to perform the task can be used as a very general measure of efficiency of the strategy adopted. Total time included the time at the supply table as well as time actually constructing the design. It turned out to be impossible to separate out the time spent constructing the design, because many children did not use the available containers to transport the needed pieces to the work table and were constantly running back and forth between the two tables. The results for total time are given in Table 4.

Table 4
Total Time in Minutes to Complete the Design

| Condition | Trial | Grade K | 2 | 4 | 6 |
|---|---|---|---|---|---|
| NM | 1 | 7.22 | 5.88 | 5.17 | 4.28 |
| | 2 | 6.05 | 5.25 | 4.15 | 3.67 |
| | 3 | 6.34 | 5.12 | 3.41 | 3.45 |
| MD | 1 | 11.62 | 9.14 | 5.59 | 4.80 |
| | 2 | 9.76 | 7.90 | 4.78 | 4.25 |
| | 3 | 9.78 | 6.72 | 4.75 | 3.69 |
| ND | 1 | 5.39 | 5.28 | 5.07 | 3.13 |
| | 2 | 6.56 | 4.78 | 5.07 | 3.63 |
| | 3 | 6.96 | 5.26 | 4.74 | 3.57 |

A 4 (grade) x 3(condition) x 3 (trial) analysis of variance indicated significant overall effects for grade ($F = 25.18$, df 3, 84, $p < .01$), condition ($F = 14.16$, df 2, 84, $p < .01$), and trials ($F = 10.47$, df 2, 168, $p < .01$). The grade by condition interaction ($F = 2.94$, df 6, 84, $p < .05$) may be explained by the greater difference between conditions at kindergarten than at higher grades. In fact, Kindergarteners in the MD condition took significantly longer to complete work on the design than did children in the other two conditions (Duncan's test, $p < .05$). A significant condition by trial interaction ($F = 6.66$, df 4, 168, $p < .01$) was apparently due to a lack of decrease in time over trials in the ND condition.

This would be expected, since the relatively short time taken by children in the ND condition was due, in part, to memory limitations; over trials, they tended to remember the design better and, thus, have more pieces to place. In short, in terms of this traditional measure of performance, modeling did not have a beneficial effect, particularly at younger ages.

Process of constructing the design. A different measure of the efficiency of the process of constructing the design was obtained by considering the number of steps taken by the children to perform the task. A step was defined as an unbroken unit of action. It was usually bounded by short pauses, sometimes a check to the sample design, or a return to the supply table or the container for pieces; it was conceived as the smallest unit of action which could be an element in a longer unit of organized activity. Coders could identify steps with very high reliability (.97), since they very often corresponded to the placing of a single piece. The results are presented in Table 5.

A 4 (grade) x 3 (condition) x 3 (trial) analysis of variance indicated significant grade ($F = 12.17$, df 3, 84, $p < .01$) and condition ($F = 9.08$, df 2, 84, $p < .01$) effects as well as a significant trial by condition interaction ($F = 6.69$, df 4, 168, $p < .01$). The interaction is due to the fact that while the number of steps decreased over trials in the NM and MD conditions, they increased (linear trend significant) over trials in the ND condition.

Table 5
Mean Number of Steps Averaged Across Trials

| Condition | Grade K | 2 | 4 | 6 |
|---|---|---|---|---|
| NM | 21.2 | 15.5 | 13.5 | 16.1 |
| MD | 27.6 | 24.8 | 17.1 | 16.2 |
| ND | 20.2 | 18.2 | 12.9 | 10.3 |

An analysis of variance on just the NM and MD condition results yielded significant main effects for grade, condition and trials without any trial by condition interaction. The significant condition effect suggests that at younger ages, children exposed to modeling were less efficient than those in the NM condition, in keeping with the direction of findings obtained in terms of the total time measure.

The children were free to adopt any strategy in constructing the design. Since the sample design could be viewed during construction by turning to it, children were able to adopt the strategy of copying the sample design. It was possible to assess the number of times children turned and checked the sample design as one indication of such a strategy. The results for the NM and MD conditions are shown in Table 6.

Table 6
Mean Number of Checks Averaged Across Trials

| Condition | Grade K | 2 | 4 | 6 |
|---|---|---|---|---|
| NM | 41.5 | 39.6 | 39.4 | 33.6 |
| MD | 63.7 | 51.0 | 37.1 | 26.7 |

A 4 (grade) x 2 (conditions NM and MD) x 3 (trial) analysis of variance indicated significant overall effects for grade ($F = 11.18$, df 3, 56, $p < .01$), condition ($F = 4.51$, df 1, 56, $p < .05$) and trials ($F = 61.59$, df 2, 112, $p < .01$). A significant grade by condition interaction ($F = 5.28$, df 3, 56, $p < .01$) appeared to be due to the lack of a significant decrease in the mean number of checks with grade in the NM condition. Children in the MD condition checked the sample design significantly more often in kindergarten (Duncan's test, $p < .05$), but their number of checks declined significantly with grade. These findings suggest that with age children in the MD condition changed their behavior more than those in the NM condition. Very similar findings were obtained when checking at the supply table was separated from checking at the work table and analyzed separately.

It was also possible to evaluate the extent to which children construed the design as organized in the way that it was conceived to be organized by the experimenters and as presented during modeling. Pausing was defined as stopping the stream of action for a brief or a longer period of time. When children paused, they sometimes also checked the sample design, but not always. In order to use pausing as an index of the way the design was being construed, pausing was divided into that occurring in between units of the design (see Figure 1) and that occurring within such units. It was thought that the more the design was construed in the same manner as organized by the model, the more of the subject's pauses should occur between units of the design, and the less within units of the design.

A 4 (grade) x 2 (condition) x 3 (trial) analysis of variance on pausing between units for children in the NM and MD conditions indicated significant grade ($F = 3.95$, df 3, 56, $p < .05$) and trial ($F = 3.53$, df 2, 112, $p < .05$) effects. The NM children paused slightly more between units than the MD children in grades K and 2, but the condition effect was not significant. Thus, between unit pausing did not vary with exposure to modeling, but decreased with age and with trials.

Looking at within unit pausing, a 4 (grade) x 2 (condition NM and MD) x 3 (trial) analysis of variance indicated significant effects for grade ($F = 11.77$, df 3, 56, $p < .01$), condition ($F = 10.76$, df 1, 56, $p < .01$), and trial ($F = 23.09$, df 2, 112, $p < .01$). No interactions were significant. As shown in Table 7, within unit pausing was higher for children in the NM condition at all ages, although such pausing decreased with age in both conditions. The ND condition was not included in the analyses, since it was difficult to pick out intended units at younger ages; however, to the extent that the model's units were evident in their constructions, there was very little pausing within such units.

Table 7
Mean Total Within-Unit Pause Time Averaged Across Trials in Minutes

| Condition | Grade | | | |
|---|---|---|---|---|
| | K | 2 | 4 | 6 |
| NM | 2.83 | 1.91 | 1.45 | 1.44 |
| MD | 1.97 | 1.71 | 1.02 | .50 |

Since a condition effect was not obtained for between-unit pausing, the differences in within unit pausing that were obtained cannot be attributed to longer pausing in NM condition in general. It appears that although with age all children come to construe the design in terms of some units, observation of the model's actions helped the child to perceive the design as composed of distinct units.

This contention is further supported by a direct examination of the units imposed on the design by the children themselves. It was decided to define a segment of the design built by the child with a single intentionality as a chunk, whether it corresponded to the model's unit or not. Chunks could include several steps, but had to be carried through with seemingly no disruption of intention during that interval of construction. Chunks were identified by coders with good reliability 88% for all three conditions).

The results are presented in Table 8.

Table 8
Mean Number of Chunks Across Trials

| Condition | Grade | | | |
|---|---|---|---|---|
| | K | 2 | 4 | 6 |
| NM | 19.71 | 15.21 | 13.65 | 14.12 |
| MD | 20.62 | 19.21 | 13.29 | 9.92 |
| ND | 8.00 | 11.50 | 8.58 | 7.96 |

A 4 (grade) x 3 (condition) x 3 (trial) analysis of variance on the number of chunks evident during construction indicated significant main effects for grade ($F = 8.78$, df 3, 84, $p < .01$), condition ($F = 25.20$, df, 2, 84, $p < .01$) and trials ($F = 36.95$, df 2, 168, $p < .01$). A significant grade by condition interaction ($F = 25.19$, df 2, 84, $p < .01$) appeared to reflect the lack of a reduction in the number of chunks with age in the ND condition. A significant condition by trial interaction ($F = 15.62$, df, 4, 168, $p < .01$) appeared due to the fact that across trials, the number of chunks increased in the ND condition, but decreased in both the NM and MD conditions. Thus, in keeping with the findings reported for total time and number of steps, memory problems appeared to be a major factor in the performance of children in the ND condition, overshadowing other effects.

Modeling Effects. Imitation of the set of ten discrete actions shown by the model (see Table A:2) was used as a general index of imitation. Since relatively few of these actions were shown by the children, they were added across all three trials. A 4 (grade) x 3 (condition) analysis of variance indicated a significant condition effect ($F = 24.87$, df 2, 84, $p < .01$) and a significant grade effect ($F = 2.74$, df 3, 84, $p < .05$). Table 9 shows that there was some decline in overall imitation with age in all conditions, but the trend was not significant in the MD condition. The condition effect was essentially due to children in the NM condition; supplementary analyses indicated that at all ages, MD and ND conditions did not differ significantly from each other, but did differ from the NM condition. These results indicate that the behaviors chosen for modeling were not ones that children engage in spontaneously while performing this task.

Table 9
Mean Number of Imitations Summed over Three Trials

| Condition | Grade | | | |
|---|---|---|---|---|
| | K | 2 | 4 | 6 |
| NM | 3.62 | 2.00 | 1.87 | 1.75 |
| MD | 7.75 | 7.12 | 5.25 | 6.62 |
| ND | 6.00 | 7.75 | 4.37 | 5.87 |

The imitations that did occur can be considered task-related. The five actions that accounted for most of the imitations are: (1) positioning of self at the supply table, (2) use of a container to transport pieces from the supply table, (3) verbalization about the pieces, (4) positioning of self at the work table, and (5) placement of pieces forward on the work board. For example, 15 of the 32 children in the MD condition and 13 in the ND condition used a container to transport the pieces from the supply to the work table, but none of the children in the NM condition did so. In addition, those children who used the container, picked up the pieces by type and sorted them effectively within the container, particularly in the ND condition. Thus, it can be concluded that the container was used as part of a planned approach to carrying out the task rather than simply in imitation of the model.

The model's influence on the overall strategy for constructing the design was evident in other ways. The model started to make the design with the unit at the center; none of the children in the NM condition did so. Children in the MD condition adopted the model's strategy in 37.5% of the trials and children in the ND condition used this strategy on 58.3% of the trials. The difference between all three conditions was significant ($p < .05$, randomization test). A similar pattern of results obtained for the progression of actions in making the design. Almost all of the children in the NM condition used a linear progression, moving from one end of the work board to the other. In contrast to the use of this linear strategy in 96.8% of the trials by the NM children, children in the MD condition used it on 41.6% of the trials and children in the ND condition used it on 9.4% of the trials. No definite age effects were evident on these measures. It is clear that the model's approach to the task was not used spontaneously by the children in the NM condition, as well as that the children in the ND condition were somewhat more strongly influenced by the model's strategy than children in the MD condition.

Evidence that observation of the model may have led the children to understand the organization of the design in a manner somewhat different from that achieved from just looking at the finished product (the sample design) can be obtained by examining in detail the kinds of pieces that were grouped by the children into chunks. In general, pieces that were next to each other in the design and which were identical were grouped together most often. Pieces that were proximal and differed only in size were grouped together less frequently, followed by pieces that differed only in shape. It appears that color was a very salient dimension for organizing the design, in that pieces differing in color were very rarely grouped together.

Table 10

Average Percentage of Chunks with Distant Pieces Averaged Across Trials

| Condition | Grade K | 2 | 4 | 6 |
|---|---|---|---|---|
| NM | 3.8 | .37 | .86 | 3.7 |
| MD | 15.3 | 15.3 | 12.1 | 14.3 |
| ND | 22.1 | 27.0 | 16.1 | 30.8 |

Children in all three conditions chunked the pieces on the basis of proximity and similarity. However, the children who observed the model making the design also grouped into units identical pieces which were not proximal to each other. It will be recalled that the model demonstrated such grouping in building units 1, 3, and 8 as well as unit 6 of the design. Chunking of non-proximal pieces on Trial 1 was evident among grade 2 children in the MD condition, but only among grade 6 children in the NM condition. As shown in Table 10, the percentage of chunks of 2 pieces or more that included distant pieces was greatest in the ND condition and quite infrequent in the NM condition, despite the fact that the number of pieces chunked increased significantly with age in all conditions.

## Discussion

The results of the present study indicate that observation of a model influences the way children approach and carry-out a complex non-verbal task even when they have other ways for performing the task successfully. A number of factors were found to modify the effects of observing a model.

First, imitation of the model seems to depend on the relation of the actions modeled to the task to be performed. In the present study, in which the child's task was made clear and imitation was not required in order to succeed at it, very little imitation of incidental actions was observed at any age studied. Imitation of incidental behaviors may peak in the preschool years, when children may have greater difficulty in determining which of the model's behaviors are task-relevant and which are not. In the present context, even the Kindergarten children may have been able to see the unimportance of most of the incidental behaviors modeled.

Although the overall imitation of the model was significant, there were some suggestions in the results that older children were less likely to adopt even the task-relevant, but unessential behaviors of the model. For example, the use of a container to transport materials from the supply table to the work table was much more frequent among Kindergarten children and grade 2 children than among the older children in both the MD and ND conditions. Therefore, age may not be related to imitation directly, but only through the child's ability to use the model's actions as a source of information and to sort out the actions that are relevant from those that are not for the adequate performance of the task.

As for the model's effect on overall task performance, there were indications that the model's effect was also greatest at younger ages. On several measures, differences between the groups exposed to the model and children in the NM condition were greater at younger ages. Differences between NM and MD conditions in terms of the number of errors, the total time to perform the task, the number of checks to the sample design, and the number of steps to perform the task were greater at Kindergarten and grade 2 than at grades 4 and 6. It would be possible to interpret the model's general effect as an increase in the care with which the younger children exposed to the model performed the task: they took longer, checked the sample design more frequently, and ended up with fewer errors. This interpretation is challenged, however, by other evidence indicating that the strategy for performing the task was affected. The differences mentioned above can be seen as an outcome of attempts to adapt the model's strategy as well of greater "carefulness". The age effects can be interpreted as due to differential success in understanding and in carrying out the model's strategy.

That children exposed to the model attempted to adapt the model's strategy in constructing the design is most clearly shown in their attempts to deal with the total design as an organized whole: to start building it at the center to delineate units within the whole by chunking more pieces, to organize actions around building those units with fewer pauses in the process, to relate pieces even when they are not in physical proximity in the design, and to work on non-adjacent portions of the design in succession. Since the model's strategy was quite complex, attempts to adapt it resulted in lower efficiency at younger ages for children in the MD condition. The NM children, particularly from Kindergarten, made the design one piece at a time, going from left to right, erring only when they lost their place in the sample design. The MD children were more variable, sometimes trying to act like the model, at other times using the piece-by-piece approach. In the process, they took longer, checked the sample design more while selecting the pieces at the supply table and while constructing the design, but made fewer errors. That the demonstration of a complex strategy can have a disorganizing effect on children who find it difficult to use has been reported recently for grade 2 and 6 children given four-dimensional discrimination learning problems (Richman, 1976). Having observed a complex strategy which is not fully grasped, the child seems to attempt to assimilate it rather than sticking to easier and surer strategies. In the process, the child may perform less well than when using the easier strategy. Thus, the major function of observation may be to perturb the set of patterns of action, to introduce variability into behavior, and thus facilitate the construction of new approaches to tasks.

The distinction between process and product may be important to keep in mind. In terms of Alford and Rosenthal's (1973) usage, children in the NM condition were given target modeling, i.e., they were shown the product to be constructed, but not a specific strategy for attaining the product. When evaluated in terms of a product measure-accuracy of the design constructed - children in the NM condition differed little from children in the MD condition, bearing out Alford and Rosenthal's finding that both live modeling and target modeling are effective. However, when the process of arriving at the product was assessed, clear differences were obtained. The main characteristics of the model's strategy (working on the design as a whole, grouping pieces into units) were approached only by the grade 6 children in the NM condition. Consequently, in considering the effectiveness of live modeling, target modeling, modeling with rule provision, and verbal instruction alone, it may be important to differentiate effects on the observer's actions in arriving at the product and on the nature of the end-product.

In the present study, verbal instructions were not given with respect to the process of design construction. A number of studies recently have suggested that verbal instruction is as effective as modeling or that modeling with verbal instruction is more effective than modeling alone. The results reported here with respect to age differences and efficiency are limited to the case of modeling without verbal instruction.

Moreover, a recent study by Clarke, Manton, Viney, and Hayes (1975) indicates that the effectiveness of modeling without verbal instruction may depend on the cultural experience of the children involved; children from western cultures seem to be more affected by modeling accompanied by instruction, but modeling alone may be equally effective for children from other cultural groups, in which demonstration rather than verbal instruction is frequently used in social interaction.

Repetition of task performance was included in this study in order to consider the cumulative effects of observation. Although there were reliable changes with repetition on practically all measures used, repetition of the task did not seem to affect children exposed to modeling differently than children merely repeating the task performance. In this context and with just three repetitions, modeling did not seem to produce multiplicative effects.

The ND condition was introduced in the expectation that without the sample design during performance, children in this condition would be most strongly influenced by the demonstration. In terms of adopting the model's general strategy (e.g., starting at the center, grouping distant pieces into units), they were. However, the memory demands of the task were so great, that most measures reflected more the memory aspect of this condition than modeling effects. An easier task would have been preferable.

In summary, the present study suggested that any age trends in imitation may be a function of the child's ability to understand the organization of the model's actions and of the pertinence of those actions to the task to be performed as it is understood by the child. Certainly, imitation of the model can itself be taken as the task by the child, or the child may be specifically instructed to imitate the model. However, aspects of the model's behavior that are seen as irrelevant to the task do not seem to be imitated without such specific instruction. Moreover, it was suggested that modeling effects on the process of task performance and on the task product need to be differentiated. Strong effects on the process of task performance in terms of strategy adoption may lead to a product that is less matched or less "correct" if the modeled strategy is not fully grasped by the child. This distinction is particularly applicable to complex, rule-governed tasks.

## Study II
## Children's Understanding of Sequential Patterns

Children's understanding of sequentially organized actions has been studied relatively little. The observations made in the previous study indicated that the design construction task used in that study was construed by the children to be organized in much simpler units than the ones that the model demonstrated through her actions. The units formed by the children were largely based on both proximity and identity of pieces or, by the older children, on identity except for variation in some one dimension. More complex rules for organizing units based on seriation, nesting, or finite iteration of a sub-unit were rarely evident in the children's actions. Even with repeated modeling, the organizational rules utilized by the model appeared to be too complex to be readily picked up by elementary school age children. Furthermore, it was not clear to what extent the presence of the sample design during construction induced a copying strategy with reliance on the most simple rules for organizing the construction task. Consequently, it was decided that the previously used task was not suitable for investigating the kind of organizational rules that children are able to pick out either from observing the actions of another or from being shown the end-product to be constructed.

The present study was undertaken with the aim of examining more closely the rules that children use to organize such graphic material in order to find a task more suitable for the general purposes of this investigation. In accord with the plan to use a non-verbal task which could be construed and carried-out in several different ways, a version of the serial pattern continuation task was chosen for this study.

A sequence can be said to entail a pattern in that it can be generated by a systematic application of a set of rules. Simon and Katovsky (1963) revived the current interest in the problem of human ability to acquire concepts or rules for sequential patterns. They pointed out that while the attainment of most concepts is measured by ability to identify instances of the concept, the attainment of the rules for sequential patterns can also be tested by asking subjects to produce new instances of the concept by generating the continuation of the pattern. Their studies have been concerned with developing a model for the kind of processes that enable human subjects to handle serial patterns so that from an example subjects are able to induce the rules governing a pattern, to remember them, and to eventually produce the sequence from the remembered rules. To test their model, Simon and his co-workers have relied on computers and studies of adult subjects, using mostly the English alphabet as the ordered series of elements for their patterns. Besides Simon and his co-workers (e.g. Greeno and Simon, 1974), other investigators have also pursued the problem of serial pattern learning and the coding strategies that may be employed by human subjects (Gregg, 1967; Restle, 1970; Vitz and Todd, 1969).

The serial pattern continuation task appeared appropriate for the present investigation for several reasons. First, the rules governing the pattern could be varied in difficulty. Second, these rules could be presented through the already-constructed part of the sequence shown to the subject or demonstrated through the actions of a model constructing the sequence. Third, in extrapolating from the example and generating a continuation of the pattern, the subject would demonstrate the rules that have been attained by means of productive action; there would be no need for generalization tasks to determine the acquisition of a rule (cf. Zimmerman and Rosenthal, 1974a). Finally, with graphic material, the rules could be embodied in different dimensions of the elements to see whether such dimensions influence the induction of the rules and the continuation of the pattern. The linear design used in the previous study did not contain a systematic variation of the different dimensions that could be used for generating units (proximity, color, shape, size, number) and, thus, could not be used to determine whether some dimensions are more easily utilized by children than others.

The only study in which the serial pattern coninuation task had been used with children that could be found in the literature was that by Klahr and Wallace (1970). Although in the article it was indicated that several 5-6 year old children were exposed to such problems repeatedly in the course of a year, the data presented were derived from one 6-year old child. The problems consisted of series composed of a single geometric shape having a distinguishable orientation, with the pattern rules embodied in the color dimension and in the orientation dimension, varied either conjointly or separately. Several series composed of whole integers or letters were also used. It was reported that children of the age studied were able to handle such problems, but tended to deal with only one dimension at a time. It was suggested that transition to Piaget's concrete operational thinking might be required for the simultaneous handling of more than one dimension in inducing the rule for the pattern.

The present study aimed to determine whether with age and cognitive development children are able to induce different rules for continuing serial patterns. To characterize the developmental change, a distinction was proposed between concrete rules describing the example given and generic rules. Concrete rules (similar to Klahr and Wallace's "template-building" strategy) would permit continuation of the pattern through repetition of the example; generic rules would permit production of new examples fitting the rules. Development was proposed to follow this order:

1. There is no induction of rules. The elements in the example are viewed individually rather than in relation to each other. Continuation does not appear to be rule-bound.

2. The rule concerning the periodicity of the sequence is grasped, i.e., the example is viewed as composed of units. However, the specific rules governing relations of units to each other or of elements within units are not grasped or utilized.

3. Non-generic rules are induced from the example, but the various rules are not coordinated with each other. For example, a stem consisting of three-element units, with each unit composed of differently-shaped pieces with variations in size might produce the rule "they come in three's, some are triangles, some are squares, and some are circles."

4. Non-generic rules are coordinated with each other or there is evidence for one generic rule. The generic rule for the above example might be expressed as "Each three piece unit must be a different shape." Coordination of two concrete rules might be expressed as "One unit must be triangles, the next squares, and the next circles; the middle triangle is small, the middle square is larger, the middle circle is still larger."

5. Generic rules are coordinated. For the same example, this might be expressed as "Each three-piece unit is a different shape and the middle piece in each unit gets progressively larger."

Examples allowing for continuations at any of the five levels outlined were selected for study. Moreover, the dimensions of color, form, and size were used to delineate units and to code relations between units as well as between elements within units in order to determine whether the rules were more readily induced when embodied in particular dimensions. The literature on perceptual salience of various dimensions suggests that color is more salient for younger children than for older ones (e.g. Odom and Mumbauer, 1971), but that even children five to seven years old make fewer errors when form is the relevant dimension in a concept identification task. Hierarchies of dimensional salience have been found to change with development for the dimensions of form, color, number, and position and dimensional salience has been shown to relate to performance on problem-solving tasks in which different dimensions are relevant (e.g., Odom and Guzman, 1972; Odom and Corbin, 1973). In a recall task, subjects from grade 1 and 4 were found to make fewer errors when the two identifying dimensions of stimulus cards were both highly salient than when only one was. In the latter case, subjects tended to rely on the one highly salient dimension (Odom and Corbin, 1973). Consequently, the dimensions of form, color, and size were systematically varied across tasks in the present study, although their perceptual salience was not assessed independently.

## Method

Subjects. A total of 90 subjects were tested, 18 each from grades 1, 3, 5, 8, and 11. The subjects were balanced for sex in each grade and came from the public school system of Worcester, Mass. An additional six subjects from the first grade and one from the third grade were tested, but not included in the sample, because they failed to perform adequately on the preliminary tasks or failed to complete all tasks.

Materials. Simple geometric forms (squares, circles, triangles, diamonds, ellipses, and rectangles) cut from 1/4 in. thick masonite in different sizes and painted several different colors (red, yellow, blue, orange, brown, green) were used to form the stems for the different serial patterns presented to the subjects. The exact description of the materials for all the tasks is given in Appendix Table A: 3.

Shallow wooden boxes measuring 11 in. x 13 in. and containing three unequal size compartments were used to present the materials for continuing the sequences to the subjects. The boxes contained all the pieces needed to build two more units of the pattern according to the rules embodied in the stem, pieces necessary to repeat the stem from the beginning, and a few additional pieces resembling those in the stem for all four problems in that series. The total of 44 pieces were located in no particular order in the box, but spread-out as much as possible to increase the visibility of individual pieces. A different box was presented to the subject for each series of tasks.

Procedure. All subjects were tested individually by a male experimenter in a spare room in their school. An adult female was also present and recorded the child's selection of pieces for each task, as well as the time to complete each task. An exact record of the child's continuation of the pattern was made. The testing session lasted about 20 minutes.

Each child was given three preliminary tasks to acquaint him with the type of task to be presented and to ensure understanding of the instructions used. The first task consisted of six brown and orange equal-sized squares laid out in alternation; the child was asked "What piece comes next?" and told "Try to continue the pattern. You can use the pieces from this box." The next task consisted of red diamonds and triangles alternating by two's. The third task consisted of triplets made up of yellow squares alternating between smaller and larger-sized pieces between triplets. For both of these tasks, the instruction was simply "Try to continue the pattern." If on one of the first two tasks a subject chose an inappropriate piece, the experimenter removed the piece and verbally highlighted the rule for the pattern (e.g., for the second task, E would say "There are two diamonds, two triangles, two diamonds, one triangle. What comes next? Try to continue the pattern.") If a subject still had difficulty with the third task, that subject was not included in the sample for the study.

After successful performance on the preliminary tasks, subjects were told "I am going to show you some patterns that might be more tricky". They were urged to examine the pattern carefully before constructing the continuation and to take as long as they wanted. They were then shown the already-constructed stems for eight patterns, one at a time, and told "Take a good look and try to continue the pattern" after the presentation of each stem. Each continuation constructed by the subject was accepted, but no feedback or reinforcement was given.

The stems of these sequences consisted of three 3-piece-units and the first piece of the fourth unit. The sequences were divided into three sets according to the dimension which changed between units; there was a color set, a form set, and a size set. Each set contained four sequential patterns. The first two patterns exemplified the use of a novel value on some dimension between units as well as for one element within the units. The third pattern exemplified an alternation rule for triplets, similar to that used in one of the preliminary tasks. The fourth pattern exemplified the use of a novel value on one dimension between units and a rule for changing the position of pieces within units (inversion or rotation). The stems for the sequential patterns in all three sets are depicted in Figure 3.

The subjects were presented with two of the three sets of tasks; pilot testing suggested that the younger children would not be able to complete all three sets in a single session. Six subjects from each grade were given the color set and the form set, six others were given the color set and the size set, and the remaining six were given the form set and the size set of tasks. Thus, each type of set was given to twelve subjects. The presentation order of the two sets given to each group of subjects was counterbalanced across subjects in that group.

The children were required to continue each pattern by adding five pieces to the stem, i.e. to complete one unit and to construct another whole unit. The pieces chosen were recorded as well as the time taken to put down the first piece and to put down all five pieces. Subjects were permitted to correct themselves. If they appeared to be looking for a piece they could not find, they were asked what it was and were given help in obtaining such a piece. However, this did not occur very often.

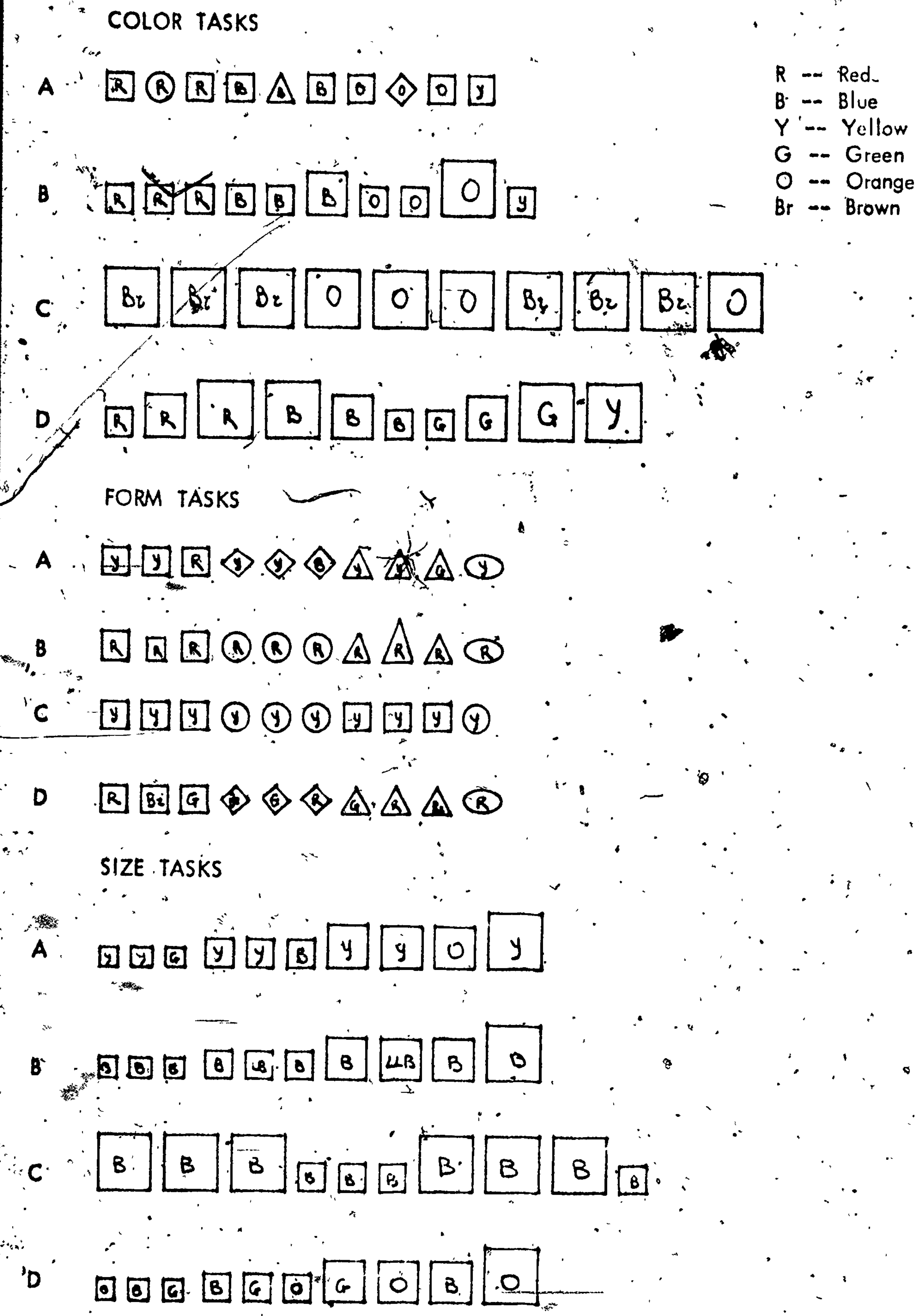



Figure 3. The stems for the sequence continuation patterns presented in Study II

Table 1
Category System Used to Score Pattern Continuations

| | |
|---|---|
| Category 1 | Continuation gives no evidence that the stem was construed as composed of distinct units. This level includes repetition of the stem. |
| Category 2 | Continuation gives evidence that the stem was construed as composed of units, but the units are other than triplets or they do not follow the between and within unit rules embedded in the stem. |
| Category 3 | Continuation gives evidence of recognition of units in the stem on the dimension of contrast between units, but no novel values of the dimension are used and no within unit rule is consistently applied. |
| Category 4 | Continuation gives evidence of recognition of units and of both within and between unit rules, but none of them include a novel exemplification. |
| Category 5 | Continuation gives evidence of the recognition of units and of a novel exemplification of either the between or the within unit rule, but no evidence for the other rule. |
| Category 6 | Continuation gives evidence of recognition of units and of both within and between unit rules, one of which includes a novel exemplification. |
| Category 7 | Continuation gives evidence of recognition of units and of novel exemplification of both within and between unit rules. |

Category System. Based on the progression of steps outlined in the introduction, a seven-level category system was constructed to evaluate the continuations produced by the subjects. This category system is given in Table 1. The protocols of 15 subjects were scored independently by the two judges, yielding 98% agreement. The few disagreements were resolved through discussion and the remaining protocols were scored by only one judge.

## Results

Preliminary analyses were carried out to determine if there were any order of presentation effects. Due to the low number of instances of categories 2 and 5, categories 2 and 3 as well as categories 4 and 5 were combined for these analyses, yielding five categories. Twelve chi-square analyses were performed (one for each task), with data collapsed across grades, to see whether order of presentation of the task was associated with the category level. No evidence for order effects was obtained and order was not included as a variable in subsequent analyses. The results regarding time to complete these tasks will not be presented, since they did not appear informative.

Age Effects. To test the hypothesis that with age there is an increasing induction of the rules embedded in the pattern's stem as well as an increasing ability to apply these rules in continuing the pattern, both parametric and non-parametric analyses were carried out on data scored using the seven-level category system.

Two 5(grade) x 3 (set) analyses of variance were performed using each group of six independent subjects for the three sets of tasks in each grade (i.e., separate analyses were conducted on the sets administered first and on the sets administered second). The levels assigned for each task were added for the four tasks in each set to obtain a subject's score for each set. Grade was found to be a significant factor in the analyses on the first grouping of subjects ($F = 6.12$, df 4, 75, $p \leq .01$) as well as on the second ($F = 4.05$, df 4, 75, $p < .01$). The mean scores for both groupings are given in Table 2. There was no significant effect for set or for interaction of grade and set.

Table 2
Mean Category Level Scores Across Tasks for Each Grade

First Grouping of Subjects

| Set | Grade 1 | 3 | 5 | 8 | 11 |
|---|---|---|---|---|---|
| Color set | 4.83 | 9.67 | 8.67 | 14.50 | 11.67 |
| Size set | 6.33 | 7.17 | 7.33 | 13.00 | 13.83 |
| Form set | 6.83 | 12.00 | 11.00 | 10.83 | 10.50 |
| Overall | 6.00 | 9.61 | 9.28 | 12.78 | 12.00 |

Second Grouping of Subjects

| Set | Grade 1 | 3 | 5 | 8 | 11 |
|---|---|---|---|---|---|
| Color set | 8.67 | 11.17 | 8.67 | 11.50 | 15.00 |
| Size set | 5.00 | 7.17 | 13.33 | 11.00 | 10.83 |
| Form set | 6.33 | 7.17 | 9.33 | 13.33 | 9.33 |
| Overall | 6.67 | 8.50 | 10.44 | 11.94 | 11.72 |

The effect of age was also examined by means of 12 Kruskal-Wallis analyses of variance conducted separately for each task within each set. In general, the finding of changes in performance with age was corroborated, but there were exceptions. In the color set, with color delineating units, the grade effect was significant for each task. In the size set, the grade effect was significant for each task with the exception of Task C, the simple alternating pattern. Here, performance by younger children was at a higher level than on the other tasks. Finally, in the form set, the grade effect was not significant for any of the tasks. Younger subjects performed at levels comparable to those on the other sets, but the older subjects did not perform as well as on the other sets, minimizing age differences. The results of these analyses are shown in Table 3.

Table 3

Results from Kruskal-Wallis One-Way Analyses of Variance for Grade Effect

| | | |
|---|---|---|
| Task A | | |
| Color Set | $H = 9.33$ | $p < .06$ |
| Size Set | $H = 11.09$ | $p < .05$ |
| Form Set | $H = 6.52$ | N.S. |
| Task B | | |
| Color Set | $H = 10.09$ | $p < .05$ |
| Size Set | $H = 12.35$ | $p < .02$ |
| Form Set | $H = 6.45$ | N.S. |
| Task C | | |
| Color Set | $H = 13.14$ | $p < .05$ |
| Size Set | $H = 2.79$ | N.S. |
| Form Set | $H = 5.44$ | N.S. |
| Task D | | |
| Color Set | $H = 18.69$ | $p < .001$ |
| Size Set | $H = 12.83$ | $p < .02$ |
| Form Set | $H = 7.36$ | N.S. |

Set Differences. The two analyses of variance for grade and set effects reported above did not yield a significant set effect. The contribution of set to performance was further analyzed by performing 12 chi-square analyses on each of the possible pairs of scores on each task (Task A Color to Task A Size, Task A Form to Task A Size, Task A Form to Task A Color, Task B Color to Task B Size, etc.) for all the independent subjects available for each comparison across grades. The same collapsed category system was employed as that used to examine order effects. Few set differences were obtained. Subjects performed differently on Task B from the color set than from the size set ($X^2 = 11.25$, df 2, $p < .01$) and on Task B from the form set than from the size set ($X^2 = 15.34$, df 2, $p < .001$). Similarly, subjects performed differently on Task D from the color set than from the size set ($X^2 = 7.57$, df 2, $p < .03$) and also on Task D from the form set than from the size set

($X^2 = 8.40$, df 2, $p < .02$). These differences seemed to be due to fewer subjects scoring in the middle categories when performing Tasks B and D from the size set than on the same tasks from the other sets. With size as the dimension differentiating units, subjects either repeated the stem or constructed novel units, possibly due to the ordered change in size between units employed in the stem (increasing rather than non-directional) which may have inhibited a non-ordered repetition of units.

Task Differences. The variation in performance due to task was examined by performing a 5 (grade) x 4 (task) analysis of variance on scores resulting from adding the category levels obtained by each subject on each task from the two sets which the subject was presented. The mean scores for each task are shown in Table 4. The grade effect was significant ($F = 5.17$, df 4, 85, $p < .01$) as well as the task effect ($F = 3.17$, df 3, 255, $p < .05$). A significant grade by task interaction ($F = 2.21$, df 12, 255, $p < .05$) appeared to be due to a reduced variability in scores for Task C when compared to the other tasks. Task C, the simple alternating pattern, did not permit the introduction of novelty and, thus, could not be completed correctly and show evidence of the use of generic rules. Consequently, the scores of the older children on this task did not differ much from the scores of the children in grades 3 and 5. In addition, Task D appeared to be somewhat harder than Tasks A and B, since the scores on this task did not show as much evidence for the use of generic rules by subjects in grades 8 and 11 as did the scores for Tasks A and B.

Table 4
Mean Category Level Scores for Each Task in Each Grade

| | Grade | | | | |
|---|---|---|---|---|---|
| Task | 1 | 3 | 5 | 8 | 11 |
| A | 3.44 | 4.33 | 5.05 | 6.78 | 6.11 |
| B | 3.17 | 4.72 | 4.44 | 6.61 | 6.39 |
| C | 3.44 | 4.44 | 4.89 | 5.28 | 5.00 |
| D | 2.67 | 4.61 | 5.00 | 6.00 | 6.05 |

Cochran Q's computed on category level scores for the four tasks in each set in each grade basically substantiated the conclusions from the above analysis. Category level 3 was scored significantly more ofen for Task C (alternating pattern) than for the other tasks from grade 3 on in all three sets, with the exception of the form set in grades 3 and 8.

The general level of performance on these tasks can be depicted by showing the number of subjects who performed at a particular level on each task from the series they were given first within each grade. Table 5 shows the number of subjects who at least picked up the periodicity of the series and continued the pattern by constructing units according to the between unit rule embedded in the stem (category level 3 or better). As evident from Table 5, from grade 3 on, at least two-thirds of the subjects continued Task C appropriately.

Table 5
The Number of Subjects Performing at Category Level 3 or Higher on the Four Tasks from the First Set Administered

| | Task | | | |
|---|---|---|---|---|
| Grade | A | B | C | D |
| 1 | 5[a] | 4 | 6 | 3 |
| 3 | 8 | 10 | 12 | 7 |
| 5 | 10 | 10 | 13 | 12 |
| 8 | 12 | 13 | 14 | 14 |
| 11 | 11 | 11 | 13 | 6 |

[a] Since the number of subjects is added across the three kinds of sets, total N possible is 18.

In contrast, such level of performance was not reached by an equal proportion of subjects in the other tasks even by grade 11. Similarly, the number of subjects who picked up both the between unit rules and the within unit rules from the stem and continued the pattern so as to indicate a generic application of at least one type of rule is shown in Table 6. No more than a third of the subjects performed at this level on Tasks A, B or D (the three tasks where this level of performance was possible) even by grade 11.

Table 6
The Number of Subjects Performing at Category Level 6 or Higher on Tasks A, B, and D from the First Set Administered

| | Task[a] | | |
|---|---|---|---|
| Grade | A | B | D |
| 1 | 0[b] | 0 | 0 |
| 3 | 2 | 3 | 0 |
| 5 | 5 | 1 | 3 |
| 8 | 6 | 7 | 1 |
| 11 | 6 | 7 | 6 |

[a] Task C was excluded since appropriate continuation did not score at this level.

[b] Since the number of subjects is added across the three kinds of sets, total N possible is 18.

## Discussion

The difficulty that these tasks presented to the subjects was unexpected, however, there had been almost no empirical work done on serial pattern continuation by children previous to this investigation. The only guidelines were the study by Klahr and Wallace (1970) and the fact that the Stanford-Binet IQ Test includes the continuation of a simple form alternation as an item at MA six years. Two sources for the difficulty of these tasks may be suggested on a post-hoc basis: the materials used and the types of rules governing the pattern.

Geometric shapes were selected as the material in order to minimize the requirement of prior knowledge about the relations between elements in the series. Series using whole integers rely on the subject's prior knowledge of the number series and sometimes on the additive and multiplicative relations between numbers. Children who are just starting school may vary in the extent of such knowledge. The other source of serial patterns has been the English alphabet. Again, young children may not have equal knowledge of the order of letters in the alphabet and may not be able to induce a rule because of this limitation. The choice of geometric materials in the present study did not require any prior knowledge since no inherent relations exist between them; however, this characteristic of the materials may have created an additional difficulty, in that the subjects could not draw on any ready-made knowledge regarding possible relations and had to induce the relations from the information presented in the stem of each pattern. The abstraction of a relation may be more difficult than the recognition of a known relation. The difficulty that even Task C posed to the subjects in this study lends support to this contention. According to the distinction between rule-learning and attribute-learning drawn by Haygood and Bourne (1965), the tasks used in the present study may be viewed as having required induction of relevant rules in conjunction with relevant attributes.

Klahr and Wallace (1970) reported to have used geometric shapes for one series in their study, but the rules there applied to single elements; the problems did not require delineation of units. For example, if the outline of a short-necked bottle is used as an element in a series with one rule pertaining to the color of the bottle and the other to the orientation of the neck, the two rules may be applied to each element in turn and, in addition, they can be applied separately. The subject may determine first that the next element in the series has to point down (in an up-and-down alternation of orientation) and then determine that it has to be brown (in a brown-yellow-blue series of colors). Klahr and Wallace commented that coordination of two such rules was difficult for the children they tested. In the present study, at least three sets of relations had to be determined and coordinated. The subjects had to determine the presence of units, then determine the rule concerning change between units (e.g., new color for each unit, new shape for each unit, a larger size for each unit), and then determine the relations between elements within a unit. Tasks A and B could be more readily carried out by considering the elements singly rather than in relation to each other; that is, a subject could perform relatively well by formulating the rule that the middle element is different from the other two in form or in color. In contrast, Task D required the subject to manipulate a relation between all three elements in the prior unit in order to determine the ordering of the elements in the next unit; that is, a subject not only had to form the rule that the color of the elements rotates from right to left, but also to consider the order of the colors in the prior unit to determine the exact position of the elements in the next. The need to coordinate a greater number of rules may have been the major source of difficulty in the present study.

Despite the difficulty of the tasks, age differences emerged. With age, and presumably with cognitive development, the subjects were able to induce the rules governing each pattern more readily and to demonstrate their knowledge of these rules by constructing a continuation of the pattern. The age differences were clearest on Task A and B from the color and size sets. Since the major changes in the level of performance appeared to take place between grades 1 and 3 and again between grades 5 and 8, it seemed worthwhile to focus subsequent studies on these periods of transition. The relatively poor performance of subjects from grade 11 was surprising. The subjects from this grade were interviewed following the administration of the tasks to ask them about their understanding of the purpose of the tasks and their ideas about the rules that were involved. The interviews were not especially productive in that subjects had considerable difficulty in explicitly verbalizing the rules that they were using. However, they did reveal that a proportion of the subjects construed the task as a speed task, despite specific instruction to the contrary; consequently, they were concerned about putting down some pieces quickly rather than spending the time to figure out the rules involved. In subsequent work, it would be important to use some means to increase the motivation of the older subjects to perform well rather than quickly.

The lack of effects due to set were somewhat surprising. Prior research on perceptual dominance of various dimensions suggested that the problems in the form set may be somewhat easier than those in the other sets. Such was not the case. Age differences were least apparent in the form set, but they were essentially due to the poorer performance of older subjects rather than to better performance of younger ones. It may be that the complexity of rules involved in these tasks overshadowed any effects due to perceptual salience of the three dimensions used.

In view of the age and task effects obtained, tasks having the format of Tasks A or B from the color or size sets seemed to be the most appropriate for subsequent studies.

## Study III
## Effects of Modeling on Children's Continuation of Sequential Patterns

In contrast to the report by Klahr and Wallace (1970), the previous study in this investigation indicated that sequential patterns which require the coordination of several rules are difficult for children throughout the elementary school years. The results from the previous study did not provide specific information about the source of the difficulty. Broadly speaking, the children may have found it difficult to induce the rules for the pattern from the stem they were provided and therefore, they may not have been able to construct a continuation of the pattern according to those rules. On the other hand, they may have been able to induce the rules, but then have difficulty coordinating them and translating them into a continuation of the pattern. Oney way of attempting to delineate the source of the difficulty in these tasks is to use a model to highlight the rules involved in the stem. Better performance following observation of the model would suggest that induction of the rules for the pattern contributes to the difficulty of the task.

The sequential patterns constructed for this study were similar to two of the tasks used in the previous study (Tasks A and B) which had yielded clearest performance differences with age. These sequential patterns share two characteristics with the serial patterns based on the English alphabet used in the research with adults (e.g. Katovsky and Simon, 1973): (1) they have no unique correct continuation, although there may be good consensus in regarding one of the possible continuations as correct; (2) they can be continued indefinitely provided the rules recycle once the list of elements has been exhausted. The patterns selected had a definite "periodicity", a relation that repeats at regular intervals or is interrupted at regular intervals. Simon and Katovsky have suggested that in trying to continue a sequence, subjects first try to discover the periodicity in the sequence. Moreover, in the tasks used in the present study, the relations of "same" and "different" or "next" (in case of size) had to be applied with respect to units in the sequence or with respect to individual elements within units. The model's activity in constructing the stem was designed to highlight both the periodicity of the sequences and the relation of "different" between elements in the sequence. Even with adult subjects, there has been little research on the effect of mode of presentation or of the length of the stem presented on the coding of the pattern and the correctness of its continuation. It was not certain that observation of the construction of the stem would facilitate continuation of the sequences. However, since the modeling would be relevant to the task, it was thought that it might influence the behavior of children able to grasp rules shown. Since the previous study had shown that the biggest changes in performance occurred between grades 1 and 3 and then between grades 5 and 8, subjects for this study were selected to represent the periods of change. The effect of observing a model highlight the rules for the sequential patterns was expected to be greatest for subjects who are beginning to recognize the rules involved on their own. In addition, it was expected that changes in performance following observation of a model would take the form of the induction of an additional rule or the coordination of one rule with another; consequently, it was expected that they would result ~~in~~ continuations at a higher category-level.

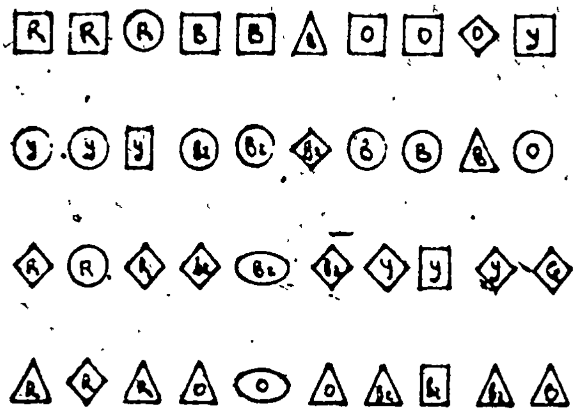
## Method

Subjects. Ninety children attending grades 2, 5, and 8 in the Worcester, Mass. public schools were tested. Thirty children, equally divided between boys and girls, were drawn from each grade and randomly assigned to either a control condition or one of two modeling conditions.

Materials. Geometric shapes cut out from 1/4 in. masonite and painted various colors were used to construct the sequential patterns.

Eight different sequences were used. The stem for each sequence was made up of 10 pieces and the subject was required to place 5 more pieces as a continuation.

COLOR -- SHAPE TASKS



R -- Red
B -- Blue
Y -- Yellow
G -- Green
O -- Orange
Br -- Brown

COLOR -- SIZE TASKS

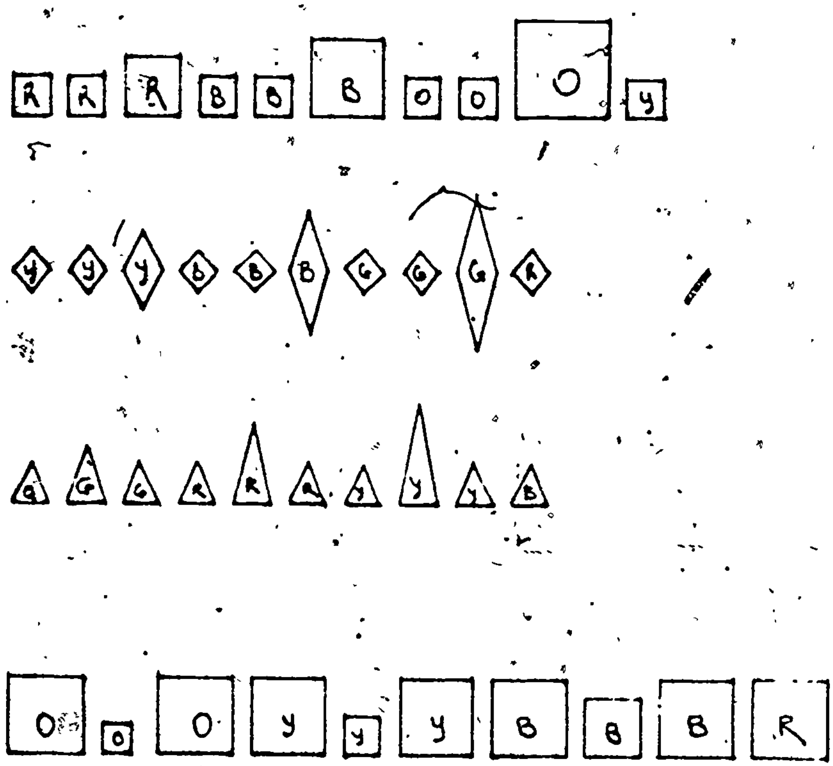


Figure 4. The stems for the sequence continuation patterns presented in Study III

All the sequences had a periodicity of 3, indicated by a change in the color of the elements (analogous to the color series in the previous study). Thus, the stem consisted of 3 units and the first element of the fourth unit; the subject was required to complete the fourth unit and construct a fifth unit for each task. The stems for the eight tasks are depicted in Figure 4.

Four of these tasks will be referred to as color-shape tasks. In these tasks, the color of the elements was constant within each triplet, but changed between triplets. The basic form of the elements was the same throughout the sequence, except that one element within each triplet (either the middle or the last one) differed in shape from the others and also from all previous different-shape elements. These tasks can be viewed as requiring the subject to find the periodicity in the sequence and then to apply the relations of "same" and "different" to the dimension of color and also to coordinate the relations of "same", "different", and "predecessor" with respect to the dimension of shape.

The other four tasks will be referred to as color-size tasks. Their periodicity was also signaled by a change in color, however, the one element within each triplet which differed from the others differed in size rather than shape. The change in size for the different element occurred in an increasing or decreasing fashion throughout the sequence. It was thought that the color-size tasks might be somewhat more difficult than the color-shape tasks in that the subjects would not only have to note a change in size, but also to order the successive changes according to magnitude.

The pieces pertinent to each task were located in a separate shallow container in which they were spread-out and semi-sorted. Each box contained two sets of pieces necessary for constructing the stem, the pieces necessary to continue the pattern, and about 10 additional pieces to permit several lower-level continuations of the pattern, or a total of about 35 pieces. If during testing the child appeared to be searching for a particular piece not in the container, the examiner questioned the child and provided it.

Procedure. All children were tested individually in a separate room in their school. An adult male served as experimenter and as model in the modeling conditions. He was seated next to the child, facing a wooden board on which the pattern was to be built and the container with the pieces for that task. Another experimenter was also present to record the subject's behavior during task performance and the continuation construction for each task. The time taken to construct the continuation was also noted, but the timing was done less conspicuously than in the previous study. Two preliminary tasks were given, similar to the ones used in the previous study. One of the tasks presented alternation of one form by color and the other alternation of same-color triplets by form. These tasks were used to make sure that all subjects understood the instruction to "continue the pattern". No subject had to be eliminated from the sample for inability to carry out the preliminary tasks.

Children assigned to the Control condition (C) were then shown the already constructed stem for each of the eight tasks in turn and were simply asked to "continue the pattern" using the pieces available in the container for each task. The order of the tasks was counterbalanced, except that the color-shape and the color-size tasks were presented in pairs.

Children assigned to the Modeling Control condition (MC) saw the experimenter construct the stem for each task by putting down the pieces one at a time slowly and deliberately, at an even pace. The model stood while building the stem and from time to time whistled. These behaviors were considered to be irrelevant to the task. Once the stem was built, the subject was asked to continue the pattern. The procedure was identical to the C condition in other respects.

The Relevant Modeling condition (RM) was designed to highlight the basic rules for each pattern. The model put the pieces down in three's in order to highlight the periodicity of the sequence. First, three pieces identical in color, form, and size were put down, then one of them was exchanged for a piece differing in form or in size, depending on the sequence. This procedure was expected to highlight the dimensions defining constancy and change for each sequence. In other respects, the model's behavior was identical to the MC condition. Once the stem was built, the subject was asked to continue the sequence just as in the other conditions.

The continuations constructed by the subjects were scored using the seven-level category system devised in the previous study (see Study II, Table 1). Scoring of a sub-sample of protocols by two judges independently showed 96% agreement in applying these categories.

## Results

Non-parametric statistical analyses were applied to data consisting of the category level scores for the continuations constructed by the subjects. Wilcoxon's Matched-Pairs Signed-Ranks Test was used to examine performance differences between tasks. The only significant difference obtained was between Task 3 from the color-shape part and Task 3 from the color-size part within grade 2 of the MC condition ( $p = .02$). It was decided that performance on the eight different tasks was sufficiently comparable to warrant the assignment of a single level score to each subject across all tasks.

Differences in the level of performance between the first four tasks administered and the last four tasks was also evaluated by the Wilcoxon test. A significant increase ( $p = .02$) in the level score from the first four tasks to the last four tasks was obtained for the grade 8 subjects in the C condition. No other significant differences were obtained. Consequently, each subject was assigned a single level score for all eight tasks irrespective of their order. In most cases, this score was the category level assigned to performance on four or more tasks. In the few instances where the level scores were more varied, the subject was assigned to that level which was manifest in the majority of his performances. For example, with three tasks at level 4, two at level 6, and three at level 7, the subject would be assigned the level score of 6, since tasks performed at level 7 include the rules evident at level 6. The distribution of the level scores obtained by subjects in each condition within each grade is presented in Table 1.

Kruskal-Wallis analysis of variance conducted on results within each condition indicated a significant grade effect in the C condition ($H = 10.82$, $df = 2$, $p < .01$) and also a significant grade effect in the MC condition ($H = 8.06$, $df = 2$, $p < .02$). The grade effect in the RM condition was not significant presumably due to the higher level scores obtained by grade 2 subjects in this condition.

Table 1

The Number of Subjects Scoring at Each Category Level Within Each Condition

Grade 2

| Condition | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| | Category Level | | | | | | |
| C | 1 | 4 | 2 | 2 | 0 | 1 | 0 |
| MC | 3 | 1 | 0 | 0 | 0 | 6 | 0 |
| RM | 1 | 1 | 1 | 0 | 1 | 4 | 2 |

Grade 5

| Condition | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| | Category Level | | | | | | |
| C | 1 | 0 | 0 | 1 | 0 | 7 | 1 |
| MC | 1 | 0 | 0 | 1 | 2 | 5 | 1 |
| RM | 1 | 0 | 0 | 0 | 1 | 4 | 4 |

Grade 8

| Condition | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| | Category Level | | | | | | |
| C | 1 | 0 | 0 | 1 | 0 | 2 | 6 |
| MC | 0 | 0 | 0 | 0 | 1 | 3 | 6 |
| RM | 0 | 0 | 1 | 1 | 1 | 2 | 5 |

Within grade 2, level of performance in the RM condition was found to be significantly higher than level of performance in the C condition (Kruskal-Wallis, $p \leq .05$), indicating that rule-highlighting modeling was effective.

The model's influence was evident in other aspects of the subjects' behavior during performance. Whistling and standing during work on the pattern were conceived to be behaviors irrelevant to the task. The whistling was done by only one grade 5 child in the RM condition. Standing was much more frequently copied, possibly because it was somewhat helpful to the younger children in attending to the whole design. A more relevant aspect of the model's behavior in the RM condition was the building of each unit from identical pieces, followed by the exchange of one piece for a different piece. Some subjects imitated these actions; others engaged in a related action whereby they first placed the two identical pieces, keeping a space for the different piece, and then inserted the different piece. These data are presented in Table 2.

Finally, the time taken to complete the tasks was examined. In terms of the level score, the color-shape tasks were found to be no easier than the color-size tasks.

Table 2

Mean Frequency of Imitation of Three Aspects of the Model's Performance

Standing During Work on the Pattern

| | Condition | | |
|---|---|---|---|
| Grade | RM | MC | C |
| 2 | 2.1 | 3.5 | 1.4 |
| 5 | 3.1 | 5.5 | .4 |
| 8 | 1.5 | 0 | 0 |

Exchanging Different Piece

| | Condition | |
|---|---|---|
| Grade | RM | MC |
| 2 | .2 | 0 |
| 5 | .1 | .1 |
| 8 | 3.1 | 0 |

Inserting Different Piece

| | Condition | |
|---|---|---|
| Grade | RM | MC |
| 2 | 1.6 | 0 |
| 5 | 1.2 | .3 |
| 8 | .6 | .1 |

A 3 (grade) x 2 (type of task) analysis of variance on the time measure showed that at all grades children took longer to complete the color-size tasks than the color-shape tasks ($F = 4.47$, df 1, 117, $p < .05$). There was also a significant grade effect ($F = 10.03$, df 2, 117, $p < .01$), with the older children taking significantly less time to complete both the color-shape tasks ($F = 8.26$, df 2, 111, $p < .01$) and the color-size tasks ($F = 5.34$, df 2, 111, $p < .01$). There was no grade by type of task interaction. These results are presented in Table 3. There was no significant condition effect ($F < 1.00$) in time to construct the continuations in any of the tasks.

## Discussion

The results obtained in this study suggest that modeling which highlights the rules governing the patterns for these sequences may affect the behavior of some children (grade 2 children in this study). Only one subject in the C condition picked up the rule pertaining to novelty (each exemplification different from all predecessors on the dimension of contrast) with respect to at least one feature of the pattern, while 7 out of 10 children in the RM condition did so.

Table 3
Mean Time in Seconds to Complete the Sequences

Color-Shape Tasks

| Condition | Grade 2 | Grade 5 | Grade 8 |
|---|---|---|---|
| RM | 166.5 | 141.0 | 136.5 |
| MC | 153.0 | 153.5 | 105.5 |
| C | 164.2 | 169.7 | 118.2 |

Color-Size Tasks

| Condition | Grade 2 | Grade 5 | Grade 8 |
|---|---|---|---|
| RM | 170.0 | 163.5 | 140.5 |
| MC | 181.0 | 193.0 | 110.5 |
| C | 166.5 | 175.0 | 120.5 |

However, an almost equal number of subjects in the MC condition also picked up the rule pertaining to novelty. It could be argued that the model's actions in building the stem for each sequence were sufficient to focus the child's attention on the pattern and, consequently, the child could more easily induce the rules involved. The results obtained do not permit an unequivocal interpretation of the modeling effect either in terms of information pertaining to the rules involved or in terms of greater attention to the task, which in itself might facilitate rule induction.

Two aspects of the findings suggest that modeling may have accomplished more than just increase the child's attention to the task. First, the conditions did not differ with respect to the time taken to construct the continuations. At least while constructing their continuations, children in the RM and MC conditions were no more deliberate and reflective than children in the C condition. Second, there was evidence that children in the RM condition imitated certain aspects of the model's strategy with respect to the within-unit rules (exchanges and insertions of pieces). Imitation of this strategy may have facilitated conception of the rules as generic.

The lack of a modeling effect in the higher grades was essentially due to a ceiling effect; that is, subjects in all conditions scored at the two highest levels on the tasks used in the present study. In comparison to the previous study, subjects in the present study seemed to find these tasks easier. Two factors may account for this discrepancy: First, subjects in this study come from a somewhat higher socio-economic background than did subjects in the previous study. In one study in which somewhat similar sequences made up of circles, squares, triangles and crosses as elements were presented to 10 1/2 year old students for extrapolation (Engemann, 1974), it was found that scores on a traditional intelligence test correlated with adoption of a more sophisticated strategy for extrapolating such sequences. It might be that the samples of children in Studies II and III of this investigation differed in intellectual level. Second, because only one basic task type was used in this study, each child was exposed to several repetitions of essentially the same task. Since no difference in the level of performance between the first half and the second half of the session was obtained, a simple learning effect does not seem to be implicated. However, the essential similarity of the tasks may have helped the children to focus in on picking up the rules involved.

Finally, it was thought that a more detailed category system might be more sensitive to performance differences. Priot to an attempt to replicate the findings of this study, the pattern continuations obtained here were used to generate a 14-level category system. Application of this category system did not alter the results, but allowed somewhat greater differentiation of performance at the higher levels.

## Study IV
## Relationship of Cognitive Abilities to Children's Continuation of Sequential Patterns

Since the sequence continuation tasks require processing of information directly pertinent to each task as well as rule conceptualization, it seems likely that performance on these tasks would be related to cognitive development. The results obtained in Study II indicated that changes in the level of children's continuations of sequential patterns occurred between grades 1 and 3 and then again between grades 5 and 8. It seemed of interest to relate the level of sequence continuations to performance on several cognitive tasks tapping concrete operational reasoning. The specific tasks chosen were thought to assess abilities that might be considered to be involved also in abstracting the rules governing such patterns. Moreover, since the ages of the children in these grades corresponded roughly to the appearance of concrete operational reasoning and the consolidation of such reasoning, cognitive tasks selected were ones that Piaget and his co-workers considered central to this period.

The cognitive tasks used included a class intersection task, a multiplicative classification task and a multiple seriation task (Inhelder and Piaget, 1964). The class intersection task requires the subject to coordinate two separate progressions and to select an object for the intersection having appropriate characteristics for both progressions. Such ability was thought to be related to that needed to coordinate the periodicity of the sequences marked by changes on the dimension indicating the units of the sequence with the constancies across units. The multiple classification task uses two dimensions for ordering the items and treats each exemplification as representing values on both dimensions. When presented in the form of a matrix, this task is facilitated by the perceptual fit of the correct element. It was thought that abilities tapped by the multiplicative classification task were related to the coordinations needed in the application of the within-unit rules in the sequence continuation tasks. The multiple seriation task requires the establishment of transitive relations along two dimensions and the coordinated ordering of these relations. It was thought that this ability might be related to the systematic ordering of changes in the variable pieces across units, particularly in the color-size tasks. The appearance of the four logical groupings associated with simple and multiplicative classification and simple and multiple seriation mark the attainment of concrete operational reasoning. Although simple seriation and class-inclusion tasks have been used in numerous studies of children's cognitive development, there have been relatively few studies concerned with multiplicative classification and multiple seriation tasks and even those were not particularly concerned with replicating Piaget's procedures (e.g. Mackay, Fraser and Ross, 1970). In the present study, Inhelder and Piaget's (1964) procedures were followed.

In addition, the sequential pattern task with geometric materials described by Klahr and Wallace (1970) was included in order to be able to compare the performance of subjects on their task with that on the types of tasks used in the present investigation.

Since the modeling effect was obtained only for grade 2 subjects in the previous study, the present study also tried to replicate the modeling effect. Only the modeling procedure that had a significant effect on performance was included. It was expected that differences in performance on the cognitive tasks would be related to the level of continuations of sequential patterns and possibly to the degree of facilitation derived from observing a model highlight the rules of the patterns.

## Method

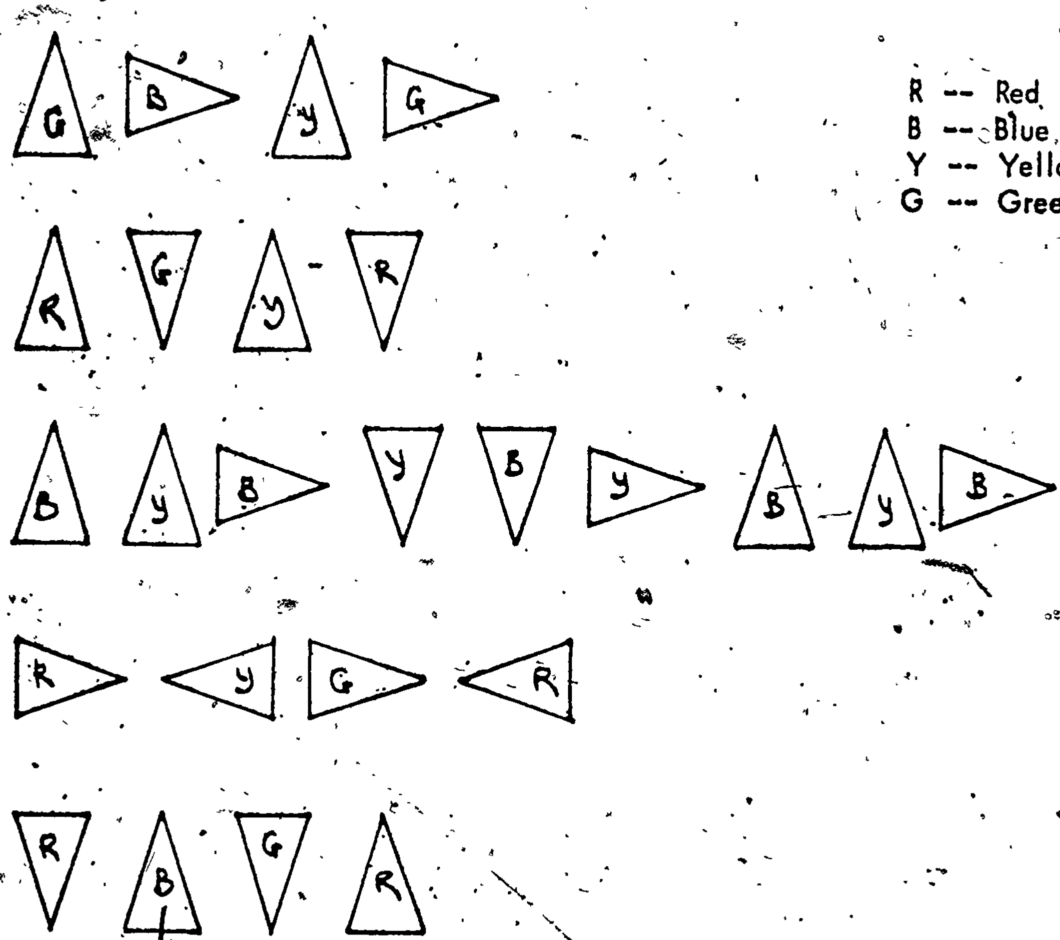
Subjects. The children were drawn from the same schools that had participated in the previous study, except that grade 3 subjects were drawn from another comparable school, because they would have been the same children who participated in the previous study as grade 2 subjects. A total of 112 children participated in this study. Twenty-two children from grade 1, twenty children from grade 2, thirty children from grade 3, thirty children from grade 5, and ten subjects from grade 8 were tested on the sequence continuation tasks. In each grade, the children were randomly assigned to one of two conditions. Nineteen additional subjects were approached (10 from grade 1, 4 from grade 2, and 5 from grade 3), but not included in the sample, because of failure to complete the preliminary tasks. Only grade 3 and grade 5 subjects were given the cognitive tasks.

Materials. For the sequence continuation tasks, the same materials were used as in the previous study.

For the cognitive tasks, the designs were drawn on heavy construction paper in colored pencil. The choices for the two classification tasks were drawn on 3 in. x 3 in. cards. The seriation stimuli were also drawn on the same size cards.

In the sequence continuation tasks modeled after Klahr and Wallace (1970), the child was presented with the stem drawn on a strip of construction paper and was asked to draw in the piece that came next in the sequence. The stems for these sequences are depicted in Figure 5.

Procedure. All the subjects were tested in a spare room in their school. For the sequence continuation tasks, the procedure was identical to that used in the previous study, except that a different adult male served as the experimenter-model and that only the C and RM conditions were employed.




R -- Red
B -- Blue
Y -- Yellow
G -- Green

Figure 5. The sequence continuation patterns modeled after Klahr and Wallace (1970)

About a month following the administration of the sequence continuation tasks, subjects in grades 3 and 5 were given the cognitive tasks in a second session. Two subjects from grade 3 had moved and were not included in the sample. The five sequence continuation tasks modeled after Klahr and Wallace were presented first. In all these tasks, color and orientation were the two dimensions relevant for the patterns and varied independently. The orientation of the sharply painted triangles alternated direction, while color repeated every third element, with the exception of one task. The subject was shown the stem of each pattern in turn and asked to "draw what comes next" after taking a good look at the pattern. Five colored pencils were made available and the child was asked to use the color which he thought was best.

Three multiplicative classification tasks were presented next. For each task, a four-fold matrix was presented already drawn with the bottom right cell empty. The subject was shown 8 choice cards from which to select one for the empty cell. The instructions were "to find the picture that goes with the other three". The subject was told that the picture selected has to fit both with the pictures in the top row and with the one on the left and was encouraged to try all eight in the space available before announcing his choice. The relevant dimensions were size and color for all three tasks. They were modeled after matrix # 9 from Inhelder and Piaget (1964, p. 161) except that the specific stimuli portrayed were geometric shapes in the first task, fishes and turtles in the second task, and fruits in the third. Performance was coded in terms of the choice made by the subject. No justification for the choice was required.

Three class intersection problems were presented next. For these problems, four instances of each class were portrayed and the subject was asked to select a picture from an array of 8 choice cards that would best fit with both progressions. The subjects were encouraged to try all 8 cards before making their final decision. The correct choice required a coordination of the dimensions of form and color, since in all three tasks one of the progressions consisted of items identical in color but varying in form and the other progression consisted of items identical in form but varying in color. Two of the tasks used geometric shapes as stimuli and the third depicted common objects.

The multiple seriation task consisted of a 5 x 5 matrix with the dimensions of size and shading varied, using circles as stimuli. All 24 cards were spread out in front of the subject in an unorganized way and the child was instructed "to arrange them in the best way you think they should go." If unseriated classes were formed, the child was asked to arrange the cards differently. If still no double seriation was produced, the experimenter seriated the largest circles in a row according to shade. The child was then instructed to "arrange what goes underneath." If again no double seriation was produced, the experimenter seriated the column of the darkest circles according to size. The child was asked to arrange the remaining cards. The arrangement made by the child after each prompt was recorded.

The expanded category system devised from the data of the previous study was used to score the sequence continuations. The category system is given in Table 1.

Table 1

Fourteen-level Category System for Scoring Sequence Continuations

| | |
|---|---|
| Category 1 | Continuation shows no recognition of pattern. |
| Category 2 | Continuation does not incorporate the last piece of the stem, suggesting no recognition of units within the stem. Use of a copying strategy was included here. |
| Category 3 | Minimal recognition of pattern indicated by the application of a "same-different" rule; this rule is not applied consistently throughout the continuation to the same dimensions of the pieces, and does not result in the construction of triplets. |
| Category 4 | Same as Category 3, except that the "same-different" rule is applied consistently to the same dimension. |
| Category 5 | Continuation shows evidence of recognition of periodicity in terms of triplets on some one dimension. |
| Category 6 | Continuation shows evidence of recognition of periodicity in terms of two dimensions, but no consistent within unit rule is evident. |
| Category 7 | Same as Category 6 above, except that a non-specific rule concerning within-unit change is also manifest in the continuation. |
| Category 8 | Continuation shows evidence of the correct grasp of between unit rules of the pattern, except for novel exemplification. A non-specific rule concerning within unit change is manifest. |
| Category 9 | Continuation shows grasp of correct between-unit rules, except for novel exemplification. Within-unit change is incorrectly specified. |
| Category 10 | Continuation shows grasp of correct between-unit rules, except for novel exemplification. Specific within-unit change rules are evident, except for novel exemplification. |
| Category 11 | There is evidence for correct between-unit rules which include novel exemplification. A non-specific rule conerning within-unit change is manifest. |
| Category 12 | Same as Category 11 above. except that within-unit change is incorrectly specified. |
| Category 13 | Same as Category 11 above, except that specific within-unit change rules are evident, but without novel exemplification. |
| Category 14 | Continuation gives evidence of correct novel exemplification of both between and within-unit rules. |

## Results

The results with respect to the effect of modeling on the level of sequence continuations essentially replicated the previous study. The level scores combined across tasks for subjects in the C condition and in the RM condition were compared within each grade using the Mann-Whitney test. No significant condition effects were obtained for grades 1 and 2. Subjects in the RM condition attained significantly higher level scores in grade 3 ($U = 54.5$, $p = .02$) and in grade 5 ($U = 27$, $p = .002$). In grade 8, the condition effect was not significant. The level scores attained in the two conditions are given in Table 2. The finding of a significant modeling effect in higher grades than in the previous study was thought to be due to the time in the academic year when the two studies were conducted. The previous study was conducted late in the academic year, so that the grade 2 subjects had almost completed work in that grade. In contrast, this replication study was conducted in the beginning of the school year, so that children in grade 3 were just starting work for that grade. Moreover, the lack of a significant modeling effect in grade 2 was partly due to the small N. When data for grade 2 subjects from both studies were combined (N = 20 in each condition), a significant modeling effect was obtained ($U = 117$, $p \leq .05$).

Table 2

The Distribution of Level Scores Attained by Subjects in the Two Conditions

| Grade | Condition | 1-4 | 5-9 | 10 | 11-13 | 14 |
|---|---|---|---|---|---|---|
| 1 | C | 8 | 2 | 0 | 1 | 0 |
| | RM | 5 | 3 | 0 | 2 | 0 |
| 2 | C | 6 | 3 | 0 | 1 | 0 |
| | RM | 4 | 1 | 2 | 3 | 0 |
| 3 | C | 7 | 1 | 4 | 3 | 0 |
| | RM | 1 | 1 | 5 | 6 | 2 |
| 5 | C | 5 | 1 | 6 | 2 | 1 |
| | RM | 0 | 0 | 1 | 9 | 5 |
| 8 | C | 0 | 0 | 0 | 2 | 3 |
| | RM | 0 | 1 | 0 | 2 | 2 |

Comparison of the four color-shape tasks with the four color-size tasks indicated that subjects in grade 3 attained slightly higher scores on the color-size tasks. However, performance of subjects in the RM and C conditions differed significantly on both types of tasks taken separately.

There were clear changes in performance of the sequence continuation tasks with age. Kruskal-Wallis analysis of variance showed a significant grade effect in both the C ($H = 27.5$, df 4, $p < .001$) and the RM condition ($H = 27.0$, df 4, $p < .001$). However, comparisons of adjacent grades indicated that the significant change in level of performance occurred between grades 5 and 8 in the C condition and between grades 3 and 5 in the RM condition. This finding supports the previous conclusion that observation of the model constructing the stem for each pattern increases the frequency of higher-level continuations among younger subjects.

Table 3

The Number of Subjects who Correctly Continued the Klahr and Wallace Sequences

| | | Number of sequences continued correctly | | | | | |
|---|---|---|---|---|---|---|---|
| Grade | N | 0 | 1 | 2 | 3 | 4 | 5 |
| 3 | 28 | 19 | 5 | 1 | 2 | 1 | 0 |
| 5 | 30 | 11 | 8 | 3 | 4 | 3 | 1 |

The level of performance on the cognitive tasks was generally low for both grade 3 and grade 5 subjects. Even on the Klahr and Wallace sequence continuation problems, the degree of success was low, although grade 5 subjects did better than grade 3 subjects, as shown in Table 3. The incorrect continuations were generally due to failure to coordinate the two dimensions of change; subjects either drew in the correct orientation or the correct color, but not both. There was no clear evidence that either dimension was more salient from the incorrect continuations. There was also no difference in performance between subjects in the two modeling conditions on these problems.

Table 4

The Number of Subjects who Correctly Solved the Multiplicative Classification Problems

| | | Number of problems correct | | | |
|---|---|---|---|---|---|
| Grade | N | 0 | 1 | 2 | 3 |
| 3 | 28 | 17 | 5 | 4 | 2 |
| 5 | 30 | 12 | 8 | 7 | 3 |

On the multiplicative classification problems (matrices), about half of the subjects failed to make even one correct selection, as shown in Table 4. Grade 5 subjects did somewhat better than grade 3 subjects, although the errors made seemed to be similar in both grades. Some subjects adopted a strategy of selecting a picture that matched one of the three already given in the matrix. Those subjects who attempted to coordinate more than one dimension, made two types of errors. They either focussed in on one of the pictures in the matrix, and changed it in only one dimension, keeping the two other dimensions constant, or, they selected to fill the empty cell by selecting a picture that matched the top object in some one dimension and the left-bottom object in another without considering the matrix as a whole.

Table 5
The Number of Subjects who Correctly Solved the Class Intersection Problems

| Grade | N | 0 | 1 | 2 | 3 |
|---|---|---|---|---|---|
| 3 | 28 | 14 | 3 | 5 | 5 |
| 5 | 30 | 10 | 3 | 5 | 12 |

Overall, the performance on class intersection problems was quite similar to that on the multiplicative classification problems, as shown in Table 5. There was no good relationship between performance in the two classification tasks, however, except that class intersection appeared to be achieved somewhat prior to multiplicative classification. No subject who succeeded on all three multiplicative classification tasks failed all class intersection problems, although there were some instances of the reverse. The errors made on the class intersection problems were somewhat different in the two grades. In grade 3, subjects tended to select a picture matching one of those adjacent to the empty cell. In grade 5, subjects tended to be correct on one of the dimensions, but copy the other from one of the two progressions.

Table 6
The Number of Subjects Forming a Double-Seriation Matrix After Different Prompts

| Grade | N | Spontantaneously | Top Row Seriated by E | One Column Seriated by E |
|---|---|---|---|---|
| 3 | 28 | 0 | 11 | 8 |
| 5 | 30 | 4 | 13 | 7 |

On the multiple seriation task, very few subjects even in grade 5 constructed the double seriation matrix. With help from the experimenter, a number of children succeeded in forming a matrix, as shown in Table 6. Practically no instances were observed of subjects who would seriate with grouping on only one dimension, that is, where strings of pictures seriated by size or shading would be constructed, with the other dimension kept constant, without being organized into a matrix. Such behavior was recorded by Inhelder and Piaget (1964).

Corss-classification of subjects in both grades revealed very little consistency in performance across these four types of tasks. To some extent, the low consistency in performance across the different Piagetian tasks was expected, since such low consistency has been the most prevalent finding in studies on cognitive functioning within the concrete operational period. Nevertheless, by grade 5, some consolidation should have been taking place and greater consistency might have been anticipated. More disappointing was the lack of relationship between performance on the Piagetian tasks and the level of continuation on either the Klahr and Wallace sequences or the ones used in the present study. There was no relationship even in performance on the two types of sequence continuation problems.

## Discussion

The replication of the modeling effect on the level of continuations constructed by sequential patterns suggests that observation of the highlighting of rules involved in such patterns facilitates induction of these rules in children who possess some capacity to operate with them. Modeling was not effective with the grade 8 subjects since they were performing at the top levels spontaneously, bearing out the finding in the previous study that such sequences are mastered by grade 8. With more intricate patterns that would be difficult for older subjects, modeling highlighting their rules would be exepcted to be effective for such older subjects. The limitation of the modeling influence to a particular age range should not be taken as a general finding, but as due to the particular tasks and demonstration strategies that were selected in the present study.

Given the age trend found in the level of sequence continuations, it still seems reasonable to assume that cognitive abilities are related to rule induction and rule coordination. The failure to obtain any relationship between the Piagetian tasks and performance on the sequence continuation problems may be due to several factors. First, the cognitive tasks selected may have been inappropriate, although on logical grounds they seem to tap similar abilities as the sequence continuation tasks. Furthermore, the child was asked to make a choice in the Piagetian problems and scoring was made on the basis of these choices (a fill-in procedure); a clinical procedure was not followed and explanations for choices were not elicited. It is conceivable that a more clinical and detailed administration of the Piagetian tasks would reveal relationships that were not found in the present study. Also, the multiple seriation and the miltiple classification tasks may be more difficult than has been assumed. The difficulty of the multiple seriation task has been noted in a previous study (MacKay, Fraser and Ross, 1970). Similarly, Overton and Brodzinsky (1972) found that the multiplicative and Piaget's procedure was difficult for grade 3 children. More variance in scores on such cognitive tasks may have to be obtained to show any relationship to performance on other tasks. Finally, performance may be much more context bound that has been assumed in cognitive theory. Toussaint (1974) has pointed out that various test situations which may be equivalent in terms of logical or structural demands may have very different information-processing requirements. The latter type of differences may account for the low correlations found repeatedly between performances on different tests of concrete operational reasoning. Similarly, while different types of sequence continuation tasks may demand rule induction and rule coordination, even utilizing similar perceptual dimensions, there may be sufficient specificity in the tasks to permit very varied performances on them. This latter point is supported also by the finding of little relationship between performance on the two types of sequence continuation tasks. It may be that prior to formal operational thinking, rules tend to be construed non-generically, giving considerable weight to specific contextual factors.

## Study V

## Construction and Recognition of Continuations for Sequential Patterns

The finding that modeling affects the level of continuation of sequential patterns suggested that help with the induction of the rules of a pattern facilitates performance. The present study was aimed at investigating whether the other facet of the task -- coordinated application of the rules in constructing a continuation -- accounts for some of the task difficulty. It has been found that for many cognitive activities, passive knowledge exceeds active knowledge. For example, this seems to hold for language in language acquisition (e.g., Goldin-Meadow, Seligman and Gelman, 1976) and for memory in terms of better recognition memory than reproduction memory (e.g., Brown, 1975a). Generally, in situations requiring passive knowledge, the context provides some support for the schematized knowledge that is required. Where choice has to be made among alternatives already given (recognition), the alternatives contain cues for the requisite knowledge.

The present study attempted to determine if children would show a better grasp of the rules for sequential patterns when required to recognize an appropriate continuation than when required to construct it from available materials.

### Method

Subjects. A total of 60 children, twenty each from grades 2, 5, and 8, attending Worcester, Mass. public schools, participated in this study.

Materials. The sequence continuation tasks were identical to the ones used in Study III described previously.

In the recognition part of the study, the same sequences were employed. Large 12 in x 18 in. trays were used to present the four different continuations from which the subjects had to choose the best one for each sequence. Each continuation consisted of 5 pieces taped to a different tray. The pieces were identical to the ones used in the construction part of the study.

Procedure. Each subject was tested individually in a spare room in the school. Half of the children in each grade were given the recognition part of the study first and then the construction of the sequence continuations; half participated in the two parts of the study in reverse order.

The construction part was administered in an identical manner to the control condition of Study III. For the subjects presented with the recognition part of the study first, only one of the two preliminary tasks used in Study III was given and a preliminary recognition task replaced the second preliminary task. A simple alternating pattern of a yellow and blue square was shown together with four two-piece continuations and the child was asked to select the best one. The second preliminary continuation task was shown immediately prior to the construction part of the study. For the subjects administered the construction part first, the preliminary recognition task was given immediately prior to the recognition part of the study.

The stem for each sequence was already constructed on a board and was placed in front of the subject. The four trays with the four continuations for that sequence were arranged in a 2 x 2 matrix in front of the subject to the right of the stem. The four continuations represented four different levels of performance: (1) a repetition of the stem from the beginning, equivalent to no recognition of units; (2) completion of the fourth unit by repetition of the first piece of that unit twice and then a repetition from the beginning, equivalent to a recognition of only the periodicity in the sequence; (3) continuation manifesting both between and within-unit rules, but with novelty only for the between-unit rules; (4) coordination of both between and within-unit rules with novel exemplification. These continuations were taken to represent category levels 1, 3, 6, and 7 in the category system used in Study II. The position of the highest-level continuation was rotated through the four cells of the tray arrangement across tasks.

An adult male served as experimenter. A second experimenter recorded the choices made by the subjects in the recognition part of the study as well as the continuations they constructed. The seven-level category system was used to score the results since it had been employed in divising the alternatives from which the subjects were asked to choose in the recognition part of the study.

## Results

Both the continuations constructed by the subjects and their recognition choices were coded in terms of category level. Analyses were conducted to examine for the effects of order of administration on both the construction and the recognition level scores. Order was significant only for the construction scores on one of the eight tasks for grade 5 subjects (Mann-Whiteney $U = 21$, $p < .05$). It was concluded that order was not a significant variable and was disregarded in subsequent analyses.

Table 1
The Number of Subjects Performing at Each Category Level in the Construction of Continuations

| | Category Level | | | | | | |
|---|---|---|---|---|---|---|---|
| Grade | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 2 | 4 | 5 | 4 | 4 | 0 | 3 | 0 |
| 5 | 1 | 0 | 3 | 1 | 2 | 11 | 1 |
| 8 | 1 | 0 | 0 | 1 | 3 | 3 | 12 |

Kruskal-Wallis analyses of variance on level scores showed a significant grade effect for constructions as well as for recognitions ($H = 12.2$, $df = 2$, $p < .01$ for recognitions). With age, children obtained higher level scores as shown in Table 1 and in Table 2. The results from the construction part of the study bear out the findings of Study III in that by grade 5, the children recognized both between and within-unit rules, but did not use novel exemplifications, while by grade 8, novel exemplifications were used by the majority of the children. In the recognition part of the study, grade 2 subjects tended to select randomly from among the four continuations presented to them. Grade 5 subjects divided their choices about equally between category 6 and category 7 continuations, while grade 8 subjects selected mostly category 7 continuations.

Table 2
The Number of Subjects Selecting Each Level of Continuation in the Recognition Part

| | Continuation Level | | | |
|---|---|---|---|---|
| Grade | 1 | 3 | 6 | 7 |
| 2 | 4 | 5 | 7 | 4 |
| 5 | 2 | 2 | 9 | 7 |
| 8 | 1 | 0 | 4 | 15 |

A comparison of the level scores for constructions and for recognition choices by means of the Wilcoxon's test revealed that recognitions were at a higher level than constructions for subjects in every grade (Grade 2, $T = 14$, $N = 18$, $p < .01$; Grade 5, $T = 12$, $N = 12$, $p = .05$; Grade 8, $T = 0$, $N = 6$, $p = .05$). The same comparison carried out for each task individually revealed significantly higher recognition than construction scores on all tasks in grade 2. In the two other grades, recognition scores were higher only on two of the eight tasks, one a color-shape task and one a color-size task. The lack of significance in these specific task comparisons was mainly due to the high level scores obtained by subjects in the construction part of the study, resulting in many instances of no difference between recognition and continuation scores.

## Discussion

The results from this study supported the hypothesis that children have a better grasp of rules involved in sequential patterns than they manifest in the continuations that they construct. The finding is similar to a report regarding construction and recognition of seriation (Blackstock and King, 1973). However, the significant age trend for the recognition choices indicates that the difficulty is not mainly in the construction process. The younger children select continuations at a higher level than ones they build on their own, but they do not select the ones at the very highest level. Consequently, it seems that with development, there is increasing understanding of sequential patterns and ability to coordinate different rules specifying the patterns. Before this understanding is shown in the continuations constructed by the child, it can be manifest in the choices of already-built continuations. Previous studies in this investigation have shown that this understanding can be elicited through exposure to contexts that provide more information about the rules involved, such as modeling.

In addition, the superiority of recognition over construction performance suggests that at the level of concrete operational reasoning, the understanding of sequential patterns may be more concrete than generic; that is, the pattern may be known only in terms of the elements through which it is presented. Because of this concrete understanding, novel extrapolations of sequences may be difficult, more difficult than reconstruction of the pattern as already given in the stem. The choice of continuations involving novelty in the recognition part may be due to perceptual pulls of the design rather than to a generic understanding of the rules involved. Thus, the concrete form of understanding of these patterns would suggest that specific aspects of such tasks should have an important role. Those tasks in which the configurational aspects highlight the pattern may be easier than those without distinctive configurational supports for the pattern. Considerable variation in performance across types of materials might be expected. Findings from Study III of this investigation, in fact, bear out such an expectation.

## Study VI
## Continuation and Memory of Sequential Patterns

In his more recent writings, Piaget has drawn the distinction between figurative and operative aspects of knowledge (cf. Piaget, 1969). By the former, he refers to knowledge derived from direct perception which includes specification of perceptual properties and concrete attributes through images and perception-based schemata. Operative knowledge, on the other hand, refers to the schemes of intelligence constructed in the process of interaction with the world, but abstracted so as to serve as generic rules for cognitive activity. It is recognized that in intellectual activity. the individual employs both figurative schemata and operative schemes, yet it has been difficult to specify exactly how the two types of knowledge interact and support one another. Inhelder and Piaget (1964) have commented that it is often difficult to specify their interaction in a concrete task except through an empirical study. Nevertheless, as a result of their studies on classification, Inhelder and Piaget concluded that multiplicative operations do not spring from the earlier graphic structures despite the perceptual support that the matrix layout of the multiplicative classification problems provides for the child. Rather, multiplicative operations and additive operations are said to be constructed in parallel steps and in interaction with each other. Recently, Toussaint (1974) also raised the issue of the relation between figurative and operative aspects of knowledge in the period of concrete operational reasoning. While demonstrating that greater synchrony in performance on concrete operational tasks can be obtained if they are equated with respect to their figural aspects, this study also found a close parallel between the more operative and the more figurative measures of reasoning. Thus, it concluded that the effect of figurative aspects of tasks must be specifically evaluated rather than ignored in assessing logical competence. Despite the recognition of the importance of the problem concerning the relation of figurative and operative aspects of intelligence, relatively little is known about the role played by figurative supports in intellectual activity. Often this problem is subsumed under context or situational effects in intellectual functioning.

Figurative knowledge clearly plays a role in specific memory, although memory generally relies to a large extent on abstract schemes (cf. Piaget and Inhelder, 1973). For example. the greater proficiency of recognition than of reproduction memory seems to indicate that figurative aspects are important, although other skills influence performance in memory tasks (Brown, 1975b). In view of the findings in previous studies of this investigation that conceptualization of sequential patterns seems to be offected by the opportunity to rely on the figurative aspects of the situation, the present study was conducted to explore this factor further. In both Studies III and IV it was found that observation of a model constructing the stem for a sequence in such a way that the different rules governing the sequence were concretely demonstrated facilitated continuation using those rules. Similarly, in Study V it was found that children selected higher-level continuations from a set of continuations than they constructed on their own. These differences in performance can be seen as indicating that figurative factors help to represent the rules governing sequential patterns and to utilize them in constructing continuations of such patterns. In the present study, the level of continuation of sequences was compared to memory for such sequences.

In addition, since some task differences were obtained in Study II due not only to the type of pattern involved but also to the perceptual dimension which was used to code a particular rule, the present study systematically explored the form-color dimensions within these tasks, since these two dimensions have been most frequently studied in the literature dealing with the effects of perceptual dominance on concept formation.

Method

Subjects. A total of 64 children, 33 from grade 2 and 31 from grade 5 served as subjects. They were drawn from Worcester, Mass. public schools and were equally divided between boys and girls. Three additional grade 2 subjects did not complete the preliminary tasks and were excluded from the sample. The children from each grade were assigned randomly to one of two task conditions.

Materials. Simple geometric shapes painted different colors were used as elements for the sequences. Six different geometric shapes were used: square, circle, triangle, diamond, ellipse, and rectangle. The pieces were painted in red, blue, green, yellow, orange, and brown colors. All the pieces were 1 1/2 in. high, except that one of the preliminary tasks used 1 in. pieces and the other - 2 in. pieces.

The stems for the sequences were presented to the child on a wooden board ( 5 ft. x 5 in. ). The pieces from which the child was asked to construct a continuation of the sequence or to reconstruct the stem were presented in a shallow wooden container ( 11 1/2 in. x 13 1/2 in. ).

Procedure. Each child was tested individually by a female experimenter in a spare room in the school. The experimenter sat opposite the child and recorded the child's behavior in constructing the sequences.

The children assigned to the Color-tasks condition (CT) were given tasks in which color change marked the periodicity of the sequence; the elements were identical in color within a unit and differed in color from all other units. Those assigned to the Form-tasks condition (FT) were given sequences in which form change marked the periodicity of the sequence. Additional within-unit rules for sequences in each condition were marked by changes in the other dimension; i.e., in the CT condition, differences in form specified the within unit rules. Thus, neither condition relied purely on form or color for the pattern of the sequences.

All subjects were given two preliminary tasks appropriate to the condition to which they were assigned. The first preliminary task involved the alternation of a single element and the second task involved the alternation of a three-element unit. Those tasks were used to make sure that the subjects understood the instruction "to continue the pattern". For each of the tasks, once the child had continued the sequence, the pieces making up the pattern were mixed up and the child was asked to reconstruct the sequence from memory. Those children who could not successfully perform the two preliminary tasks were excluded from the sample.

The 16 subjects in the CT condition within each grade were administered eight color-shape tasks. These tasks presented four different patterns: (1) an alternating pattern; (2) a pattern in which either the last or middle piece of a unit is different from the other two and from all previous different-shape pieces; (3) a repetitive pattern in which all the pieces within a unit are of different shape from each other, but retain their positions across units; (4) a repetitive pattern in which all the pieces within a unit are of different shape from each other and rotate from right to left in their position across units. These patterns were similar to those employed in Study II. Two tasks represented each pattern. The subjects in the FT condition were given analogous patterns except that form was used to designate units. The stems of the sequences used in the present study are shown in Figure 6.

For all patterns, the units were composed of three elements. Each stem consisted of three units and the first piece of a fourth unit. To continue the sequence the subject was required to complete the fourth unit and to construct a fifth unit. In reconstructing the pattern, the subject was requested to put down what he could remember, but scoring was based on the first three units of each sequence. For the continuations there were 27 pieces in the container for each task given to the subject, representing a repetition of the stem, a correct continuation, and various pieces needed to construct a variety of intermediate continuations. For the reconstructions, the child worked with the 15 pieces representing the stem and the continuation constructed by the child.

The four types of patterns were presented in counterbalanced order across subjects; the two tasks of the same type were presented one after the other. After completion of the preliminary tasks, the subject was first asked to "continue the pattern" and forewarned "I want you to remember the pattern, too" before each of the eight tasks in turn. Once the continuation was constructed, the pieces were mixed up and the subject was asked "Now, do you remember how the pattern went?" and told "Try to put down as much as you can remember."

The continuations were scored using the 14-level category system employed in Study IV. The reconstructions were scored for accuracy in terms of the number of pieces remembered correctly as well as for the level of rule-coordination manifest in the reconstruction. Since two tasks were administered for each type of pattern, the higher of the two level scores was used as the subject's score for that type of pattern.

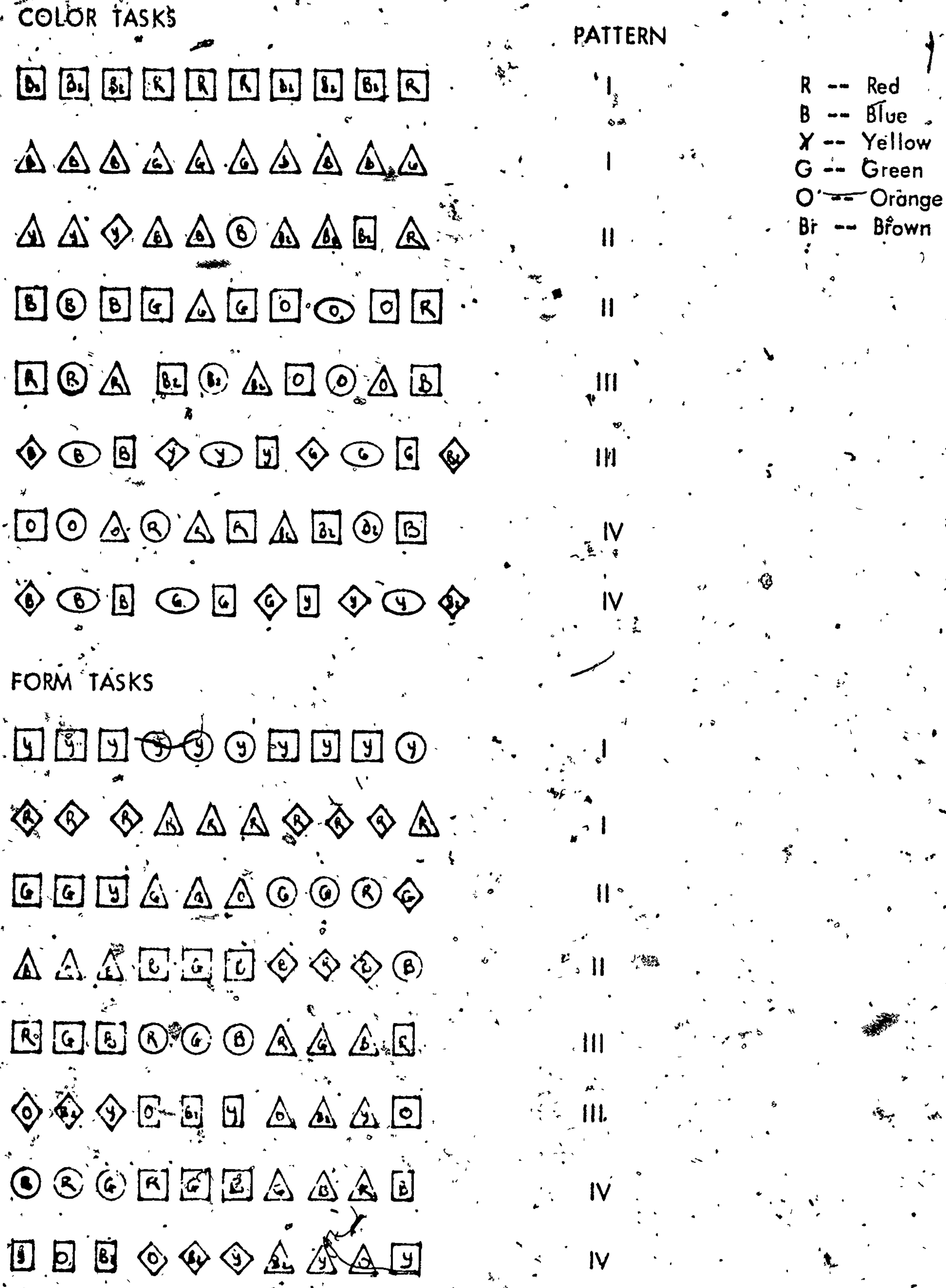



Figure 6. The stems for the sequence continuation patterns presented in Study VI

## Results

Preliminary analyses indicated the sex of subject and order of task presentation were not significant variables and were disregarded in subsequent analyses. Analyses of variance were used as a first step in analyzing the data.

A 2 (grade) x 2 (condition) x 4 (type of pattern) analysis of variance on the level scores obtained for continuations indicated that grade 5 subjects scored higher than grade 2 subjects ($F = 6.52$, df 1, 60, $p < .05$) and that CT subjects scored higher than FT subjects ($F = 7.74$, df 1, 60, $p < .01$). The grade by type of pattern interaction was also significant ($F = 3.05$, df 3, 180, $p < .05$), apparently due mainly to different performance on the third type of pattern, on which grade 5 subjects tended to do better relative to the other types.

A 2 (grade) x 2 (condition) x 4 (type of pattern) analysis of variance on the level scores obtained for reconstructions of these patterns showed a significant grade effect ($F = 6.65$, df 1, 60, $p < .05$), condition effect ($F = 9.74$, df 1, 60, $p \leq .01$), pattern effect ($F = 11.41$, df 3, 180, $p < .01$), and a significant condition by pattern interaction ($F = 6.38$, df 3, 180, $p < .01$). Grade 5 subjects obtained higher scores on reconstructions than grade 2 subjects and subjects in the CT condition obtained higher scores than subjects in the FT condition. In view of the apparent importance of the type of pattern, analyses of variance were carried out on each type of pattern separately.

A 2 (grade) x 2 (condition) x 2 (continuation/reconstruction) analysis of variance on level scores for the first type of pattern (alternations) indicated that reconstruction scores were higher than continuation scores ($F = 9.06$, df 1, 60, $p < .01$). No other significant effects were obtained. As would be expected from performance on the preliminary tasks, alternating patterns were within the competence of subjects from both grades. The mean level scores are shown in Table 1.

Table 1
Mean Level Scores for Continuations and Reconstructions of the Alternating Pattern

| | | Condition | |
|---|---|---|---|
| | | CT | FT |
| Grade 2 | Continuations | 8.82 | 7.94 |
| | Reconstructions | 9.53 | 9.25 |
| Grade 5 | Continuations | 9.33 | 8.75 |
| | Reconstructions | 10.00 | 10.00 |

A 2 (grade) x 2 (condition) x 2 (continuation/reconstruction) analysis of variance on level scores for the second type of pattern (one different element within each unit, see Figure 6) indicated that grade 5 subjects achieved higher scores than grade 2 subjects ($F = 6.18$, df 1, 60, $p < .05$), that CT subjects achieved higher scores than FT subjects ($F = 13.76$, df 1, 60, $p < .01$), and that reconstruction scores were higher than continuation scores ($F = 44.90$, df 1, 60, $p \leq .01$). None of the interactions were significant. The results are shown in Table 2.

Table 2

Mean Level Scores for Continuations and Reconstructions of the Second Pattern

| | | Condition | |
|---|---|---|---|
| | | CT | FT |
| Grade 2 | Continuations | 8.88 | 6.81 |
| | Reconstructions | 12.12 | 8.75 |
| Grade 5 | Continuations | 11.07 | 7.94 |
| | Reconstructions | 14.00 | 11.19 |

For the third type of pattern (each piece a different shape within the unit, see Figure 6), a 2 (grade) x 2 (condition) x 2 (continuation/reconstruction) analysis of variance indicated that grade 5 subjects scored higher than grade 2 subjects ($F = 8.50$, df 1, 60, $p < .01$), CT subjects achieved higher scores than FT subjects ($F = 8.43$, df 1, 60, $p < .01$), and that reconstruction scores were higher than continuation scores ($F = 48.87$, df 1, 60, $p < .01$). There were no significant interactions, since the relatively lower reconstruction scores of grade 5 subjects were due to low scores of a few subjects. The results are shown in Table 3.

Table 3

Mean Level Scores for Continuations and Reconstructions of the Third Type of Pattern

| | | Condition | |
|---|---|---|---|
| | | CT | FT |
| Grade 2 | Continuations | 8.41 | 6.44 |
| | Reconstructions | 11.88 | 9.69 |
| Grade 5 | Continuations | 11.87 | 13.87 |
| | Reconstructions | 9.00 | 11.31 |

For the fourth type of pattern involving a within-unit rotation rule (see Figure 6), a 2 (grade) x 2 (condition) x 2 (continuation/reconstruction) analysis of variance showed no grade effect, apparently due to lower scores on these tasks by grade 5 subjects. The CT subjects scored higher than the FT subjects ($F = 4.33$, df 1, 60, $p < .05$) and reconstructions had higher scores than continuations ($F = 56.54$, df 1, 60, $p < .01$). There were no significant interactions. The results are shown in Table 4.

Table 4

Mean Level Scores for Continuations and Reconstructions of the Fourth Type of Pattern

| | | Condition | |
|---|---|---|---|
| | | CT | FT |
| Grade 2 | Continuations | 8.18 | 7.50 |
| | Reconstructions | 10.94 | 11.19 |
| Grade 5 | Continuations | 10.60 | 8.00 |
| | Reconstructions | 12.53 | 10.87 |

In sum, for all tasks, reconstructions achieved higher scores than continuations and, with the exception of the alternating pattern, subjects in the CT condition achieved higher scores than subjects in the FT condition. Grade 5 subjects performed better except on the fourth type of pattern; the within-unit rotation rule was found to be difficult in Study II as well. With the alternating pattern, grade 5 subjects constructed and reproduced correct continuations, therefore, the lack of a grade effect was due to the easiness of the task.

To follow-up the apparently better performance on reconstructions than on continuations, Wilcoxon's tests were conducted on the level scores achieved for each task within each grade. For subjects in the CT condition, reconstruction scores were significantly higher for all tasks with the exception of one of the rotation-rule tasks for grade 5 subjects. For subjects in the FT condition, significantly higher reconstruction scores were not obtained on two tasks within each grade, but the tasks were not the same. For grade 2 subjects, the differences were not significant for tasks representing the second type of pattern, while for grade 5 subjects, the tasks representing the fourth type of pattern were equivalent. Overall, however, these non-parametric analyses supported the conclusion that reconstructions manifested a higher level of rule usage than continuations.

The reconstructions were evaluated in terms of accuracy as well. Accuracy was determined by counting the number of pieces in the same positions as in the stem given to the subject by the examiner. A 2 (grade) x 2 (condition) x 4 (type of pattern) analysis of variance on accuracy of reconstruction scores indicated that grade 5 subjects were more accurate than grade 2 subjects ($F = 10.12$, df 1, 60, $p < .01$) and that subjects in the CT condition were more accurate than subjects in the FT condition ($F = 7.74$, df 1, 60, $p < .01$). This effect was modified by a significant grade by condition interaction ($F = 12.44$, df 1, 60, $p < .01$). Subjects in grade 2 were about equally accurate in both conditions, but subjects in grade 5 were more accurate in the CT condition. The type of pattern effect was significant as well ($F = 98.92$, df 3, 180, $p < .01$). The mean accuracy scores for the different types of patterns are shown in Table 5.

Reconstruction accuracy scores ordered the four patterns in difficulty from Pattern I to Pattern IV in both conditions in the same way as they had been ordered using the level scores. As clear an ordering of the four types of patterns in difficulty was not obtained using the sequence continuation data.

Table 5
Mean Reconstruction Accuracy Scores for the Four Types of Patterns

| | | Pattern | | | |
|---|---|---|---|---|---|
| Grade | Condition | I | II | III | IV |
| 2 | CT | 7.0 | 4.4 | 3.6 | 2.0 |
| | FT | 8.3 | 4.2 | 3.5 | 2.1 |
| 5 | CT | 9.0 | 7.3 | 5.8 | 3.3 |
| | FT | 7.8 | 4.4 | 3.0 | 2.3 |

Consistently, subjects in the CT condition performed at a higher level than subjects in the FT condition to the extent that grade differences were not apparent in the FT condition on some tasks. At first glance, this finding may appear contradictory to the literature indicating better performance on concept formation tasks with form as the relevant dimension. It must be recalled that both form and color were relevant to specify all the rules for the tasks used in the present study. However, in the CT condition, form specified the within-unit rules, while in the FT condition, it delineated the units of the pattern. Evidence obtained in previous studies suggests that specific within-unit rules are induced by subjects with greater difficulty than the between-unit rule. It may be that coding the more difficult within-unit rules through the more perceptually salient form dimension facilitates the recognition of those rules and results in higher level or more accurate performance.

## Discussion

The better performance on reconstructions than on continuations supports the hypothesis that figurative aspects of the pattern facilitate its representation. This evidence is in accord with that obtained in previous studies concerning better recognition of correct continuations and the effect of modeling on level of continuations in suggesting that the cognitive competence to induce the rules for these patterns may be insufficient for their full utilization at the time when such competence is first being developed; it is in this period that performance can be facilitated through contextual supports. It should be noted that the difference between continuations and reconstructions was clearer for grade 2 subjects than for grade 5 subjects, since the latter were able to perform at higher levels in the construction part of the study. These results parallel the findings on modeling effects, since modeling was found to have a greater impact on younger than on older subjects.

The ordering of the four types of patterns in difficulty is of interest. That the alternating patterns are the easiest is not surprising, since they are defined by a smaller number of rules; except for rules specifying the identity of elements, no other specific within-unit rules are employed. There can be no novel exemplifications and the highest category levels do not apply to them. The second type of pattern was identical to that used in Studies III, IV and V. This type of pattern was slightly less difficult than the third type of pattern in which all three elements within a unit differed from each other, but remained identical across units. In this third type of pattern, there is no within-unit novelty possible, but there is a larger number of relations between elements within a unit that must be specified. It was thought originally that this third type of pattern might be easier than the second type, since there is no requirement to do an across-units comparison to determine the characteristics of a within-unit element. However, this was not the case. Either the greater number of relations within the unit made up for the across-units comparison, or the repetitive change in the same position across units in the second type of pattern added salience to the change and counteracted the added cognitive demand of the additional comparison. Restle (1973) has suggested on the basis of work with adult subjects that structural complexity does not account completely for the difficulty of serial patterns, since subjects use a variety of operations to organize the patterns. In any case, the difference in difficulty between the second and the third type of pattern in the present study was not great. The fourth type of pattern was the most difficult, as might have been expected. The rotation rule for specifying the position of specific elements within units requires a manipulation of all three elements in relation to each other and a comparison back to the previous unit to obtain an anchor point for the rotation. This fourth type of pattern proved quite difficult even for grade 5 subjects.

The clear relation between the difficulty of the pattern and the number of rules that need to be coordinated to specify that pattern suggest that an anlysis of the conception of sequential patterns in terms of constituent rules is a meaningful procedure. Moreover, it suggests that different ways for conveying information to the subjects about the rules governing a pattern should facilitate comprehension of the pattern in parallel with findings regarding acquisition of other concepts.

## Study VII
## The Effects of Modeling on Construction and Recognition of Sequential Patterns

The previous study demonstrated that children could reconstruct a sequential pattern from memory better than they could continue it. Although it was argued that their greater facility with reconstructions was due to the support that the figurative aspects of the already-constructed stem gave to the organization of the pattern, the study did not rule out the possibility that simple memory for the location of a few of the pieces in the stem may have produced the higher reconstruction scores. For example, Blackstock and King (1973) found that different figural arrangements facilitated recognition than reconstruction in a seriation task. Consequently, it was thought desirable to contrast children's ability to continue a sequential pattern with their ability to construct the same pattern with new materials of varying similarity to the original. Consequently, in the present study, rather than being asked to reconstruct the pattern with identical materials, children were asked to reconstruct it with novel materials.

A second aim of this study was to tie in the effect of observing a model highlight the rules governing a pattern with children's ability to continue sequential patterns and to reconstruct them. It seemed of interest to determine whether the effect of observing a model was specific to the pattern and the materials that the model had used or whether it would generalize to the construction of the same pattern with novel materials. Moreover, since previous studies had shown the effectiveness of modeling when contrasted with a condition in which the child does not witness the construction of the stem, the present study examined two modeling conditions that differed only in the extent to which the rules governing the pattern were emphasized in the model's actions. Studies of modeling have found that addition of verbal rule statement to modeling enhances the modeling effect (e.g., Zimmerman, 1974).

To further investigate the role of the specific materials in the child's understanding of sequential patterns, children were asked not only to continue the patterns, but also to choose from among four alternatives a pattern most similar to the sequence they had just seen. In contrast to Study V, however, the choices were constructed from materials different from the ones used to present the sequence. The novel materials were identical to the novel materials provided for the reconstruction of the patterns. In this way, reconstruction could be again compared to recognition, but in this study the patterns were embedded in novel materials. It was again expected that there would be better performance on recognition than on construction.

In sum, the aim of the present study was to bring together the various ways that had been used to enhance children's conceptualization of sequential patterns (modeling, recognition) and to examine the generalization of the understanding of such patterns to new materials. Two age levels from the range at which the understanding of sequential patterns had been found to be most modifiable were selected to permit some analysis of changes with development in the effects of the variables employed.

## Method

Subjects. A total of 64 subjects, 32 from grade 3 and 32 from grade 5 participated in the study. Two additional grade 3 subjects were excluded from the sample due to failure on the preliminary tasks. The subjects were drawn from two public schools in Worcester, Mass., both situated in a similar middle-class neighborhood. Within each grade, the subjects were equally divided between boys and girls. Half of the children in each grade were randomly assigned to one of two modeling conditions.

Materials. Three different types of materials were used in this study. The first type consisted of geometric shapes cut out from masonite and painted different colors. The shapes included: square, circle, triangle, diamond, ellipse, and rectangle; the colors used included: red, blue, green, yellow, orange, brown. All the pieces were 1 1/2 in. high. These materials had been used in the previous studies of this investigation and were employed in the presentation of the sequential patterns.

A second type of material (Low Novelty - LN) was quite similar to the first. The same six geometric shapes cut out from posterboard in the same six colors were used in the construction and the recognition parts of the study. The pieces were again 1 1/2" high.

The third type of material (High Novelty - HN) consisted of six different configurations glued to 1 1/2" square pieces of white posterboard. The different configurations were: a single dot, an oblique line of 3 dots, a single horizontal line, a double horizontal line, a cross of two lines, and a horizontal line with a dot above it. These configurations were constructed by pasting adhesive lines and dots made from glossy paper to the posterboard. These configurations were made in the same six colors used for the other materials.

The sequences were presented on a wooden board used in previous studies and the pieces with which the children were to work on any given task were presented in a wooden or a cardboard box, as appropriate.

Procedure. All subjects were tested individually in a spare room in their school. An adult female served as experimenter and as model. A second female experimenter was present to record the child's activity in performing these tasks.

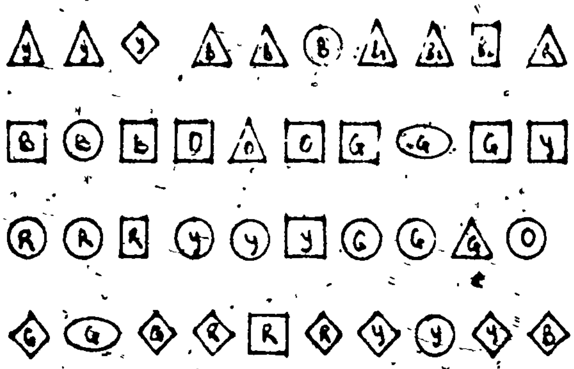
All subjects were presented with two preliminary tasks and eight sequence continuation tasks. Those in the Modeling Control condition (MC) observed the model build the stem for the sequence continuation tasks one piece at a time, at an even pace. Although the stem was constructed while the child watched, the model made no attempt to emphasize any aspect of the pattern. The subjects in the Relevant Modeling condition (RM) observed the model build the stem so as to emphasize some of the rules governing the pattern: each triplet was put down first containing identical pieces; then, the different-shape piece within the triplet was put in place of one of the identical pieces; for patterns in which all pieces within a triplet were of a different shape, a second piece was similarly replaced. This procedure was meant to highlight the periodicity and the within-unit rules of the pattern.

The eight tasks consisted of four instances each of the second type of pattern and the third type of pattern used in Study VI. For all tasks, color change marked the division of the sequence into units and form coded the within-unit rules. The eight sequential patterns are shown in Figure 7. In all cases, the stem consisted of 10 pieces, three complete units and the first piece of the fourth unit. To continue the sequence, the subject was required to complete the fourth and to build the fifth unit.

Four of the sequence continuation tasks were followed up immediately by a pattern reconstruction task and the other four by a pattern recognition task. In each grade and each modeling condition, the presentation of the reconstruction and the recognition tasks was counterbalanced across subjects. Each type of pattern was represented by two tasks in the recognition part and by two tasks in the reconstruction part of the study.

At the beginning the child was given one preliminary task. It consisted of a repetitive sequence of three squares, with each triplet marked by a different color. The child was asked to continue it in order to demonstrate understanding of the instruction "continue the pattern." Then the child was asked to remember the pattern, and if he was among those receiving the recognition part first, to select from four sequential patterns constructed from the LN materials one that was most like the pattern he had just seen. The basic shape of the elements in the choices was triangle rather than square, and a different sequence of specific colors was used to delineate the units. Each of the choices consisted of 12 pieces, but only one was a completely adequate representation of the pattern. If the child did not successfully perform on this warm-up task, it was explained and presented again. Being successful, the child was then presented with the tasks in the recognition part of the study. Children who could not succeed on the preliminary tasks were excluded

PATTERN II



R -- Red
B -- Blue
Y -- Yellow
G -- Green
O -- Orange
Br -- Brown

PATTERN III

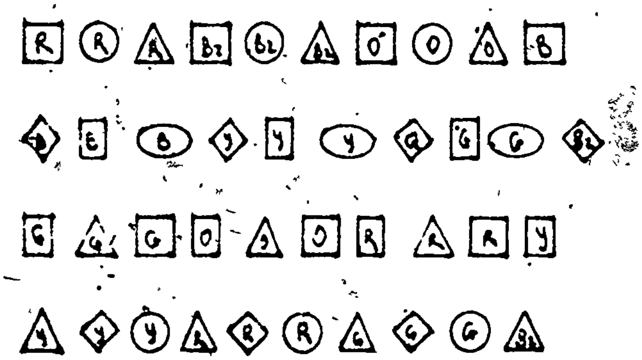


Figure 7. The stems for the sequence continuation patterns presented in Study VII

from the sample.

Before the reconstruction part of the study, a second preliminary task was given. It consisted of a simple alternating pattern of single brown and orange squares. The children were requested to continue the pattern. Once they had done so, they were asked to look it over so that they could remember the pattern. All the materials were removed and the child was presented with 16 HN pieces and asked to make a pattern as close to the one he had just seen as he could. The replication that could be made was an alternation of blue and yellow dots. Again, if the child was not successful, the task was explained and presented once more. Those who succeeded with the preliminary task were then given the four reconstruction tasks. Subjects assigned to be given the reconstruction tasks first were also given this preliminary task first.

The LN and HN materials were used with each type of pattern in both the reconstruction and the recognition parts of the study. In short, there were four children in each grade and each modeling condition who were given the reconstruction/recognition parts of the study in the same order and were asked to deal with the two types of patterns in the same order; one of the tasks representing each type of pattern was given with LN materials, the other with HN materials in both the reconstruction and recognition parts of the study.

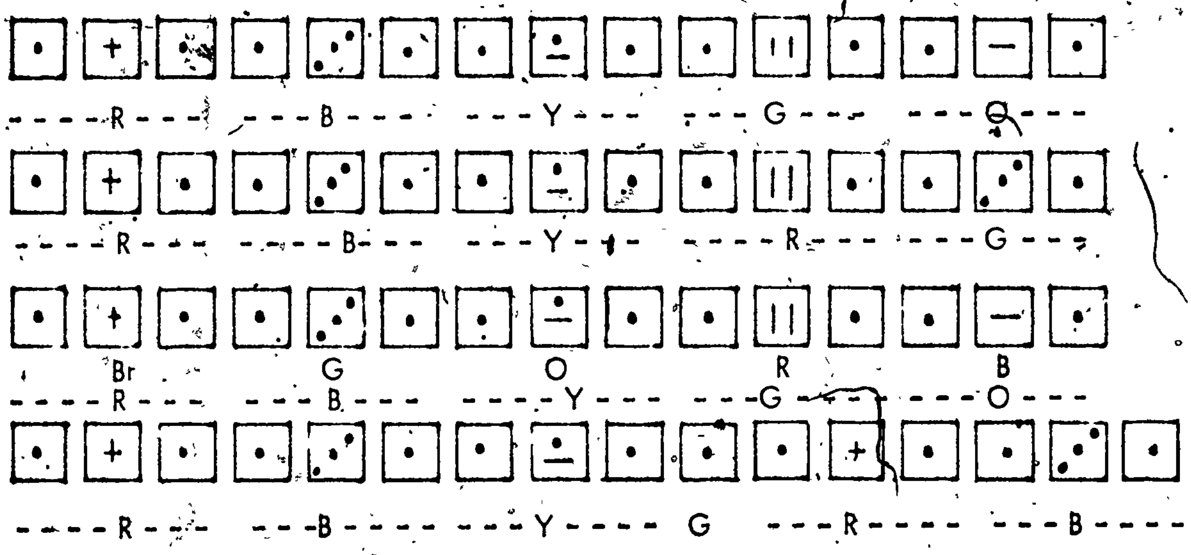
To continue each sequence, the subjects were given a box containing about 35 pieces; these included the pieces necessary to continue the pattern as well as pieces necessary to continue it in all the ways that previous studies had shown children attempt to handle these tasks. In the reconstruction part of the study, the children were given around 40 pieces of either LN or HN materials and were asked to make the pattern using these novel materials. After putting down 15 pieces (i.e., 5 triplets), the child was stopped with the statement that he had done enough. In the recognition part of the study, the child had to choose among four sequences, each containing 15 pieces. Each of the four sequences was glued to a 2 1/2 x 18 in. strip of white posterboard and represented different degrees of approximation to the pattern. In terms of the 14-level category system used in previous studies, the four choices represented category levels 2, 7, 10, and 14. The strips were lined up one above the other and the child was asked to indicate the best representation of the pattern. The position of the strips representing the various choices was counterblanced across tasks and subjects. The sets of recognition choices for two of the tasks are shown in Figure 8.

The continuations, reconstructions, and recognitions were scored using the 14-level category system described in Study IV.

## Results

The results of this study turned out to be difficult to interpret for several reasons. First, a number of the variables interacted with each other making the small N in each cell inadequate for specific comparisons. Second, in one of the schools used in the study, the majority of subjects in one grade turned out to be not from the residential area served by the school, but from a near-by housing project. In this school, grade differences obtained in previous research and with subjects from the other school tended to be either absent or reversed in direction. There was an insufficient number of subjects from each school to conduct separate analyses for each school. In some analyses, school was entered

HIGH NOVELTY MATERIALS




LOW NOVELTY MATERIALS

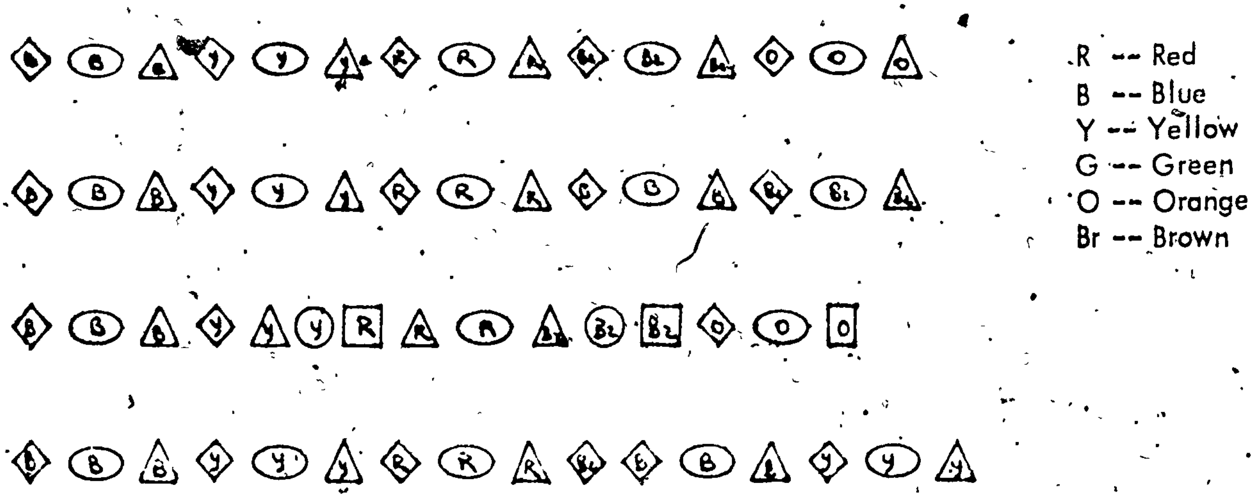



Figure 8. Recognition choices for Pattern II task in HN and Pattern III task in LN materials

in as a variable and did interact significantly with other variables. On the other hand, order of administration of specific tasks ~~and of the~~ reconstruction/recognition parts of the study was not significant. All analyses to be reported were carried out ignoring the order variable.

Table 1
Mean Level Scores of Subjects on Continuations of Two Types of Sequential Patterns

| School | Pattern | Modeling MC | Modeling RM |
|---|---|---|---|
| 1 | II | 12.04 | 11.76 |
| | III | 12.39 | 13.25 |
| 2 | II | 9.93 | 11.04 |
| | III | 10.08 | 11.30 |

Continuations of Sequential Patterns. An analysis of variance on the level scores for continuations of all of the eight sequences was carried out using grade, modeling condition, and school as between subject factors and the two types of patterns represented by the eight tasks as the within subject factor. In this study, tasks representing pattern type III (all elements of different form within a unit, repeated across units) were continued at a significantly higher level than those representing pattern type II ($F = 13.21$, df 1, 56, $p < .01$). The difference in the mean level of continuations was not large. In addition, the modeling x school x type of pattern interaction was significant ($F = 4.63$, df 1, 56, $p < .05$). It appears that in one of the schools, subjects in the RM condition constructed higher-level continuations only in tasks representing pattern type III, while in the other, RM subjects constructed higher level continuations for both types of patterns. The results are shown in Table 1. Although over-all grade and modeling effects were in the expected direction, as shown in Table 2, the variability was too great to result in significant differences.

Table 2
Mean Level Scores of Subjects in the Two Modeling Conditions
on Continuations of Sequential Patterns

| | Pattern Type II: Grade 3 | Pattern Type II: Grade 5 | Pattern Type III: Grade 3 | Pattern Type III: Grade 5 |
|---|---|---|---|---|
| MC | 10.78 | 11.19 | 11.25 | 11.93 |
| RM | 11.00 | 11.80 | 12.12 | 12.43 |

Reconstructions of Sequential Patterns. The reconstruction scores were lower overall than the continuation scores, as might be expected, since the subjects were reconstructing the patterns using novel materials. In an analysis of variance with grade, modeling condition, and school as between subject factors and type of pattern, novelty of material, and continuation/reconstruction parts of the study as within subject factors, a complex pattern of results was obtained. Continuation scores were significantly higher than reconstruction scores ($F = 105.66$, df 1, 56, $p < .01$) and reconstructions with HN materials were at a higher level than with LN materials ($F = 4.21$, df 1, 56, $p < .05$). These results were modified by a number of significant interactions.

The continuation/reconstruction scores varied with the type of pattern ($F = 15.26$, df 1, 56, $p < .01$), since the greater proficiency with tasks of pattern type III obtained on continuations did not hold for reconstructions; in reconstructions, the two types of patterns were about equivalent in difficulty. A significant grade x modeling x school x novelty of materials interaction ($F = 6.47$, df 1, 56, $p < .05$) was obtained as well as a significant grade x modeling x school x type of pattern x continuation/reconstruction interaction ($F = 4.04$, df 1, 56, $p < .05$). The effects of grade and modeling were in the expected direction, but varied also with school, type of pattern, and novelty of materials. Table 3 shows the results for grade and modeling condition.

Table 3

Mean Level Scores Obtained on Continuations and Reconstructions of Sequential Patterns

| | | Grade 3 | Grade 5 |
|---|---|---|---|
| Continuations | | | |
| Modeling | MC | 10.70 | 10.97 |
| | RM | 11.05 | 12.30 |
| Reconstructions | | | |
| Modeling | MC | 7.09 | 7.17 |
| | RM | 7.34 | 8.72 |

With pattern type III tasks, subjects tended to build reconstructions at higher levels when given HN materials than when given LN ~~materials~~ if they were in the RM condition. The modeling x novelty of materials interaction was significant ($F = 8.05$, df 1, 60, $p < .01$) when the reconstruction scores were analyzed for tasks of each pattern-type separately. There was only a trend in the same direction for tasks of pattern type II. These results are shown in Table 4.

Recognition of Sequential Patterns. Continuation scores were higher in the present study than recognition scores since all the recognition tasks were presented with novel materials. In an analysis of variance with grade, modeling, and school as the between subject factors and type of pattern, novelty of material, and the continuation/recognition part of the study as the within subjects factors, a number of significant interaction effects were obtained. Overall, continuation scores were significantly higher than recognition scores ($F = 7.99$, df 1, 56, $p < .01$). Subjects from one of the schools differed more in these two parts of the study than subjects from the other school ($F = 4.65$, df 1, 56, $p < .05$). Also, subjects in grade 5 did better with LN materials than subjects in grade 3

($F = 5.80$, df 1, 56, $p < .05$). It appeared that grade 3 subjects tried to adopt a direct matching strategy with the LN materials and failed to use the rules of the pattern in a more abstract way.

Table 4

Mean Level Scores Obtained on Reconstructions of Pattern Type III Sequences

| | | Materials | |
|---|---|---|---|
| Modeling | Grade | LN | HN |
| MC | 3 | 6.94 | 6.56 |
| | 5 | 7.31 | 6.75 |
| RM | 3 | 6.75 | 7.75 |
| | 5 | 6.75 | 9.31 |

The type of pattern in addition to the novelty of the materials affected the scores obtained by subjects in the two grades differently. The grade 5 subjects did relatively less well on tasks using the type III patterns in the recognition part of the study compared to the continuation part than did grade 3 subjects, particularly with HN materials. In contrast to the reconstruction part of the study, the grade 3 subjects did about equally well with LN as with HN materials in the recognition part of the study. Grade 5 subjects did less well with HN materials. Significant type of pattern x novelty of materials ($F = 5.28$, df 1, 56, $p < .05$), grade x novelty of materials x continuation/recognition part of the study ($F = 7.34$, df 1, 56, $p < .01$), grade x modeling x type of pattern x continuation/recognition part of the study ($F = 8.14$, df 1, 56, $p < .01$) and modeling x school x novelty of materials x continuation/recognition part of the study ($F = 9.08$, df 1, 56, $p < .01$) interaction effects were obtained. Some of these results are shown in Table 5.

Table 5

Mean Level Scores Obtained on Continuation and Recognition of Sequential Patterns

| | Grade | |
|---|---|---|
| <u>Continuations</u> | 3 | 5 |
| Pattern II | 10.55 | 11.28 |
| Pattern III | 10.90 | 11.71 |
| <u>Recognitions</u> | | |
| Pattern II LN | 9.49 | 11.79 |
| HN | 9.96 | 9.54 |
| Pattern III LN | 9.05 | 10.74 |
| HN | 10.50 | 9.17 |

When scores just on the recognition part of the study were considered, it was found that grade, modeling, and novelty of material effects were more clearly evident on tasks representing pattern type III. A 2 (grade) x 2 (modeling condition) x 2 (novelty of materials) analysis of variance on pattern type III tasks revealed that subjects in the RM condition scored lower in grade 3 and higher in grade 5 (grade x modeling condition $F = 4.70$, df 1, 60, $p < .05$) as well as that grade 3 subjects scored higher with HN materials while grade 5 subjects scored higher with the LN materials (grade x novelty of materials $F = 6.75$, df 1, 60, $p < .05$). It seems that the LN materials interfered with rule application by grade 3 subjects not only in the reconstruction part of the study, but also in the recognition part of the study.

Table 6

Mean Level Scores Obtained on Reconstruction and Recognition of Sequential Patterns

| Pattern Type II | | Reconstruction | | Recognition | |
|---|---|---|---|---|---|
| | | Grade 3 | Grade 5 | Grade 3 | Grade 5 |
| LN | MC | 6.69 | 7.50 | 9.12 | 12.00 |
| | RM | 6.81 | 8.81 | 9.87 | 12.00 |
| HN | MC | 7.56 | 7.06 | 9.75 | 8.75 |
| | RM | 8.06 | 10.06 | 10.25 | 10.50 |
| **Pattern Type III** | | | | | |
| LN | MC | 6.94 | 7.31 | 9.87 | 10.00 |
| | RM | 6.75 | 6.75 | 8.00 | 11.00 |
| HN | MC | 6.56 | 6.75 | 11.37 | 8.06 |
| | RM | 7.75 | 9.31 | 9.87 | 10.32 |

Since type of pattern affected the results of both the reconstruction and the recognition parts of the study, scores for these two parts were compared separately with tasks representing the two types of patterns, and separately for the two levels of novel materials. In all comparisons, the level scores in the recognition part of the study were higher than in the reconstruction part of the study. Thus, when the variable of the novelty of materials was equated, recognition was shown to be easier than reconstruction. The results are shown in Table 6. In addition, a significant grade effect was obtained for subjects given pattern type II tasks with LN materials, since grade 3 subjects were found to do particularly poorly in the reconstruction part of the study with LN materials.

## Discussion

The finding that subjects could reconstruct sequential patterns using different materials as well as to recognize those patterns when represented through different materials strongly supports the contention that children are inducing the rules for these patterns and are working with those rules in performing these tasks. The presence of grade differences in the expected direction on all three parts of the study further supports the contention that children's understanding of sequential patterns is tapped in continuation, reconstruction, and recognition.

Since novel materials were involved, reconstructions and recognitions were at a lower level than continuations. However, it was interesting to find that LN materials, rather than being easier, were more difficult for grade 3 subjects, particularly in the reconstruction part of the study. The experimenters observed that grade 3 children often tried to match the pieces in the sequence rather than to represent the pattern with LN materials. Since it was impossible to make a direct copy, they tried setting up equivalences (orange = red; a square = rectangle) and thus, multiplied the number of rules they had to coordinate. The HN materials did not evoke a matching strategy and even the grade 3 subjects were able to use them to represent the pattern of a sequence. This suggests that younger subjects are able to work with rules for sequential patterns, but that their preferred strategies for copying the concrete exemplification of a pattern sometimes interfere with manifestation of their understanding. This finding may have important implications for assessment of generalization of a learned concept.

The finding that performance in the recognition part of the study was superior to that in the reconstruction part supports the conclusion of Study V that a higher level of understanding can be demonstrated in situations where there are contextual supports for it. This finding fits in with the literature concerning many areas of cognitive functioning which shows better passive than active use of knowledge.

The effect of the two modeling conditions was in the expected direction, but the influence of the observation of the model was modified by several other variables. This finding fits with the results from previous studies showing that the effect of highlighting the rules governing a pattern is more clearly seen when contrasted to a no model condition rather than to a model condition in which rule demonstration is minimal. If a no model condition had been included in this study, interpretation of the findings regarding modeling would be easier. It seems that observation of the process of constructing the stem piece by piece may sufficiently parse the stem to help some subjects induce the rules of the pattern. Moreover, the effect of other variables on modeling suggests that modeling is best viewed as one variable that influences the performance on such tasks through facilitating the induction of the rules governing a pattern. The type of pattern used and the child's level of development also affect the ability to induce rules for sequential patterns.

Besides rule induction, the performance on tasks of this nature seems to be affected by the subject's ability to represent those rules and then to apply them in actual performance. Consequently, the type of material and the nature of the task (continuation vs. recognition) also affect performance. The complexity of interactions found in this study reflects the many variables that contribute to cognitive activity and influence the actual performance observed.

## Concluding Remarks

Several common themes run through the findings from the seven studies which constitute this investigation. The specific findings from each individual study have been already presented and discussed within the framework of that study. In this section, the common themes will be highlighted and their implications will be discussed in the broader context of the role of observation of models in cognitive functioning.

There have been relatively few studies concerned with the differential effects of modeling on children differing in age, despite the fact that this question is frequently raised in reviews of the literature (e.g., Hartup and Coates, 1970). As pointed out in the introduction to this report, one reason for this may be the assumption of social learning theorists that the tendency to imitate does not undergo development and only varies with aspects of the situation, characteristics of the model, and so forth. From the cognitive perspective, Piaget (1951) has conceptualized imitation as the accommodative pole of cognitive functioning, suggesting that occurrence of imitation is related to engagement of the accommodatory process. The Piagetian conception implies that overt imitation will be the product of the requirements of the situation and the cognitive level of the observer, both difficult to assess, since the understanding of the requirements of a situation also depends on the cognitive level of the observer. Aside from imitation in the period of infancy, Piaget has made few statements with respect to imitation, except to say that as assimilation and accomodation become more equilibrated with development, and as symbolic operations replace overt actions, the incidence of overt imitation declines.

The findings from the present investigation may be viewed as consonant with the Piagetian conception of imitation. At least within the age range studied (elementary school years), there was little evidence of changes in the tendency to imitate a model with age, which is not to say that there were no differences in the effect of a specific model at different ages. The above statement requires elaboration. At first glance, the findings regarding imitation of task irrelevant behaviors of the model may seem to contradict these statements. Studies I and III obtained some evidence for a decline in the imitation of task irrelevant behaviors of the model with age. However, the age trend was not significant within the purest modeling condition (MD) of Study I, and the reduction in such imitation was clear only at grade 8 in Study III, an age by which the children in that study could carry out the tasks used quite competently even without exposure to the model. The findings regarding imitation of task-irrelevant behaviors may be interpreted as reflecting the child's understanding of the task; once the task is fully understood and can be carried out competently, the irrelevance of some of the model's actions is also appreciated and dispensed with. The point has been specifically demonstrated in a different study (Sibulkin and Uzgiris, in press).

For task relevant actions, modeling effects were obtained at some ages, but not others. Invariably, the effects were strongest at a middle range of ages, for children who might be thought to have some grasp of the requirements of the task, yet to be unable to perform it competently on their own. Thus, the effect of modeling may be said to depend on the relation between the requirements of the task and the child's capacity to peform it. In Study I, in which a more difficult task was used, the effects of observing the model were evident at all age levels, although they were less evident at grade 6 than at grade K.

In Studies III and IV, in which easier tasks were employed, there was no evidence for modeling effects at grade 8, in contrast to grades 5, 3, or 2. However, grade 8 subjects performed the tasks competently even without exposure to a model. It is argued here that modeling effects would be obtained for older subjects (e.g. grade 8) and not for younger ones if the difficulty of the tasks would be increased. Similarly, it is argued that grade 1 subjects did not show a modeling effect, because for them, the tasks were hard. The findings from this investigation are consistent with this interpretation, but they are not conclusive. It would be possible to make a stronger case for this position if subjects had been presented with a series of tasks graded in difficulty and modeling effects had been consistently found for the tasks of medium difficulty at each age level. Such a study was not conducted within the present investigation. Nevertheless, on the basis of the results obtained, it is suggested that the question of age changes in responsiveness to models may be more profitably rephrased as one concerning the relationship between the subject's cognitive level and the subject's understanding of the task as well as of the model's behavior.

The approach adopted in this investigation of looking at the effects of the model's actions on the observer's approach to a task rather than just on the final product of solution is considered worthwhile, but was found to be difficult to implement. More research is needed to delineate those characteristics of actions that meaningfully reflect their organization. Nevertheless, results of the present investigation suggest that observation of a model can affect not only the frequency of discrete behaviors (as in studies by Bandura and co-workers) or the adoption of a single rule (as in the research by Zimmerman and Rosenthal), but also the very organization of actions directed toward a particular goal. Although much more research is needed to delineate the most important features of sequentially-organized actions, the present investigation indicates that modeling may influence the organization of such actions and that it is feasible to study the effects of modeling on it.

An attempt was made in Study IV to relate directly children's cognitive level to responsiveness to modeling. Failure to obtain such a relationship in that study is not sufficient to invalidate the conception of imitation presented here. The specific reasons for the failure to obtain the expected results were presented in the discussion of that study. More generally, however, that study points up the difficulty of obtaining an independent assessment for the child's understanding of a task in order to make a prediction about the effects of observing a model. It seems that task-specific and situation-specific variables modify cognitive functioning sufficiently to doom the search for relations across contexts and tasks, or least at the period of concrete operational reasoning. With more careful attention to such specific factors, it may be possible to make some progress on this issue. As Toussaint's (1974) study demonstrated, with equalization of task-specific variables, better concordance may be obtained for performance on several logical problems. Assessment of a subject's cognitive level in relation to his understanding of a complex task and of a model's performance of that task may have to be carried out with a variety of contextual variables equalized in order to adequately assess the proposed relationship.

In several studies within this investigation, an attempt was made to have the subjects convey their understanding of the task and their approach to it to the experimenter verbally after completing their part in the study. This approach was found to be generally unproductive. The children studied were usually unable to verbalize much either about the model's actions or their own. If a product was present during questioning (Studies I and II), the subjects appeared to attempt to derive a description of their own actions from the product independent of their previous behavior. Since reflection on one's own actions is a higher-level cognitive task than performance of such actions (requiring representation of one's actions) these observations need not be surprising. They are reported here to indicate that assessment of the subject's understanding of the modeling situation will also have to be conducted at the same level of representation as required by task performance.

Although accommodation to the model's actions may facilitate understanding, on the basis of the present research, modeling does not stand out as a unique mechanism for producing change in another's actions. Since the present investigation was concerned with patterns of organization found within actions which are not captured in a single verbal concept, the model's behavior was arranged to highlight the relevant rules through action rather than through verbalization. In this investigation, such non-verbal demonstration of rules was not directly contrasted with the statement of such rules verbally. Research concerned with concept attainment has demonstrated that verbal rule statement may be as effective as modeling or at least that modeling with verbal rule statement is more effective than modeling alone (see Zimmerman and Rosenthal, 1974). Whether the same would hold for concepts concerning the sequential organization of actions remains to be investigated.

The realization that context or situational variables play a much larger role in intellectual functioning than cognitive theory was assumed to imply is strongly supported by the findings of this investigation. Even without considering the restrictions on generalization arising from the characteristics of the subjects studied, almost every study described here provided evidence that any general description of children's understanding of certain organizational rules has to be modified by specifying the assessment task, the mode of testing (recognition, construction), the amount of abstraction required (LN and HN materials in Study VII), and so forth. Consequently, it seems that better specification of how such context or situational variables interact with the utilization of a particular cognitive operation is a necessary direction for future research. Orientation toward this view may have important implications for educational practice as well, in that it would sensitize all personnel to the fact that performance within one context should not be generalized to prognosticate a child's performance in all other contexts.

Moreover, focusing in on the utilization of cognitive functions within specific contexts should lead to a much more detailed analysis of the cognitive processes and operations engaged by specific tasks. Whether information theory turns out to be a useful source of concepts for such detailed analyses, or other theories have to be devised, nevertheless, these kinds of analyses would make important and useful contributions not only to understanding of cognitive functioning, but also to the educational process. The present investigation does no more than suggest some of the specific processes (unit delineation, identification of differences, coordination of differences with constancies) that may be involved in conceptualizing patterns for generating sequences from elements; it does, however, point up the need for research that would push such endeavor further.

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## Appendix

### Table A: 1

Pieces Contained in Different Compartments of the Supply Box in Study I

The supply box (30 in. x 12 in.) had 24 compartments arranged in 3 rows and 8 columns for the 400 pieces.

| | |
|---|---|
| Column 1 | 3 compartments each with yellow squares (20 in each) |
| Column 2 | 1 compartment, red circles (10);<br>1 compartment, red squares (10);<br>1 compartment dark blue ellipses (10) |
| Column 3 | 3 compartments of extraneous pieces (10 in each) |
| Column 4 | 1 compartment medium blue ellipses (20);<br>1 compartment blue ellipses (20);<br>1 compartment light blue ellipses (20) |
| Column 5 | 1 compartment red triangles (20);<br>1 compartment green triangles (20);<br>1 compartment red diamonds (20) |
| Column 6 | 1 compartment dark blue triangles (30)<br>2 compartments red sticks (15 in each) |
| Column 7 | 1 compartment longest brown sticks (20);<br>1 compartment medium long brown sticks (10);<br>1 compartment medium brown sticks (10) |
| Column 8 | 1 compartment long brown sticks (20)<br>2 compartments short brown sticks (20 in each) |

Table A: 2

Model's Behavior in Building the Design

At Supply Table:

1. M used a container* in which to place the pieces selected
2. M stood with the back to the sample design
3. M picked up pieces by type in the following order:
   a. 6 yellow squares
   b. 3 pairs of blue ellipses and 1 pair of red diamonds. Verbalized "Two of these, two of these..." while picking up the pieces
   c. 2 red triangles, 2 green triangles, and 3 blue triangles
   d. 3 red "sticks", 4 short brown "sticks", 4 long brown "sticks", and 2 medium length brown "sticks". The model picked up a handful of the red "sticks", blew on them, then dropped the rest in the box and kept 3 to be placed in the container. While selecting the brown "sticks", the model verbalized "some of these, and some of these..."
   e. 1 red square, 1 red circle, and 1 dark blue ellipse.

At the Work Table:

1. M placed the container on the table beyond the wooden board for the making of the design.
2. M started to build the design at the center.
3. M proceeded to build the design in units in a non-linear progression. The units were built in the following order:
   a. Unit 5: M placed the center dark blue ellipse and then built outward by picking up and placing two pieces together, one on each side, until the unit was complete. While placing the pairs, M verbalized "these two, and these two..."
   b. After a brief pause, M picked up the container with the left hand, walked right and built unit 8, then, M walked left and built unit 1, then unit 3, placing the pieces in their proper locations. M put the container down on the table. Thus, M crossed center twice while building these units.
   c. After a brief pause, M picked up all pieces of unit 2, walked to the left, and built the unit two pieces at a time, in order.
   d. After a brief pause, M picked up the pieces for unit 7, and put them down one at a time. The second and the third sticks were placed at a slant, then picked up, rubbed together, and placed down straight. The fourth piece was then added.
   e. After a pause, M built unit 6. M first placed the three red "sticks" with spaces in between. Then the spaces were filled in with 1 red triangle, 2 green triangles, and three blue triangles.

f. After a pause, the design was completed by building unit 4.

4. The container was returned to the supply table after completion of the design.

* These behaviors were considered incidental to the building of the design and were scored as imitations of M.

Table A: 3
The Materials Used for the Twelve Tasks of Study II

Color Tasks

A. All pieces 1 1/2 in. in size; color varies between triplets. The basic shape is square, but the shape of the middle piece within each unit varies.

B. All pieces are square in shape; color varies between triplets. Basic size of the pieces is 1 1/2 in., but the last piece of the triplet is larger in each successive triplet, increasing by 1/2 in. from 1 1/2 in. in the first triplet to 2 1/2 in. in the third.

C. All pieces 3 1/2 in. in size and all are squares; color alternates between triplets.

D. All pieces are square in shape; color varies between triplets. Each piece in the triplet varies in size by 1 in. from the others in either increasing or decreasing order.

Form Tasks

A. All pieces 1 1/2 in. in size; shape varies between triplets. The basic color is yellow, but the last piece in each triplet varies in color.

B. All pieces are red in color; shape varies between triplets. The basic size of the pieces is 1 1/2 in., but the middle piece increases in size by 1/2 in. from 1 in. in the first triplet to 2 in. in the third.

C. All pieces are yellow and all are 1 1/2 in. in size. Shape alternates between triplets.

D. All pieces are 1 1/2 in. in size; shape varies between triplets. Three different colors rotate among the three pieces in successive triplets.

Size Tasks

A. All pieces are squares; size increases between triplets by 1/2 in., with all pieces in the first triplet 1 in. in size. The basic color of the pieces is yellow, but the last piece in each triplet varies in color.

B. All pieces are squares; size increases between triplets by 1/2 in., with all pieces in the first triplet 1 in. in size. The basic color of the pieces is blue, but the shade of the middle piece decreases in intensity, starting from being identical to that of the other pieces and going to much lighter in the third triplet.

C. All pieces are squares and all are blue. The size of the pieces alternates between 4 in. and 2 1/2 in. for the triplets.

D. All pieces are squares; size increases between triplets by 1/2 in., with all pieces in the first triplet 1 in. in size. Three different colors rotate among the the three pieces in successive triplets.